Assessment of Quality of Packaged Water in Ilorin West Local Government Area, Kwara State

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Abstract: Water is vital for life; however, it also serves as the commonest route of transmission of a number of infectious diseases. In the context of growing health consciousness and chronic water shortages, most urban residents have switched to bottled water as a safe alternative. However, studies have shown that these beliefs are not always true. The aim of the study was to assess and analyse the quality of packaged water in Ilorin West Local Government Area. Sixteen samples of water from eight (8) water packaging factories were collected to give a composite sample and to avoid error. Standardized laboratory analysis was carried out on the water samples. The study reveals that out of the 16 samples of packaged water that were analyzed for various physicochemical as well as microbial parameters, 95% were above the Nigerian Industrial Standard (NIS) limit of temperature which can lead to the development of some biological contaminant. Virtually all the packaged water exceeded chloride and total hardness limit stated by NIS but all the other parameters were within NIS acceptable limits. The study concludes that the packaged water samples contained excessive heavy metals above the NIS standards which can cause various deadly health problems such as cancer, thereby making it unsatisfactory for drinking purpose. The study therefore recommends that the safety of packaged drinking water should be ensured and that testing of market samples should be supported.

Keywords: water, water quality, packaged water

INTRODUCTION

Water is an essential resource for all activities of man (such as domestic uses, agriculture and economic, spiritual, recreation uses etc.). Water has become increasingly scarce because of high demand and this has caused people to resolve to consumption of packaged water. The sale and consumption of packaged water continues to grow rapidly in most countries of the world. In Nigeria particularly, there is an astronomical increase in the consumption of packaged water especially bottled and sachet drinking water. The increased demand for these drinking water products is attributed largely to factors such as inadequate or non-availability of reliable, safe municipal water in urban areas; impression that high quality natural spring water and drinking water offer a healthy, refreshing and great tasting alternative to high calorie soft drinks and ordinary tap water; and convenience which has made the products meet the requirements of any lifestyle when needed (Gardner, 2004). According to the National Agency for Food and Drug Administration and Control (NAFDAC), majority of packaged water are produced under questionable hygienic environmental conditions, without approval and do not meet standards. Regardless of all these problems associated with packaged water, it is still considered wholesome for drinking purposes compared to tap or well water. Natural water might contain many different chemical constituents, which may be organic and inorganic. The latter may be derived from the rocks and soil through

which water percolates or over which it flows, while the organic components are derived from the breakdown of plant materials or from algae and other microorganisms that grow in the water or sediments. Chemicals used in water treatment, from industrial sources and agricultural activities may introduce contaminants in final water. While a lot of studies have been done to assess the physicochemical as well as microbiological quality of bottled/packaged water in Nigeria, relatively few of the studies has been done on the safety of packaged water vended in Ilorin. This present study is carried out to provide information on aspects of the physicochemical quality of vended packaged water as well as clarify concerns about its safety to consumers.

Therefore, the assessment of the quality of packaged water in Ilorin West is the main focus of this work so that conclusion can be drawn on the quality of bottled/packaged water after testing and comparing it with the Nigerian Industrial Standard (NIS) for bottled/packaged drinking water.

STUDY AREA

Ilorin, the state capital of Kwara State is located at latitude $8^0$30` and $8^0$50`N and longitude $4^0$20` and $4^0$35`E of the equator. Ilorin city occupies an area of about 468sq km and it is situated in the transitional zone within the forest and the guinea savannah regions of Nigeria. It is about 300 kilometres away from Abuja, the Federal Capital of Nigeria. The climate of Ilorin is tropical under the influence of the two trade winds prevailing over the country. Ilorin metropolis experiences two climatic seasons i.e., rainy and dry seasons. The rainy season is between March and October and the annual rainfall varies from 1120mm to 1500mm. The dry season commences in November and lasts till early March (Emielu, 1991). Also, this area experiences high temperature and annual average often reaches 32^0C. Rainfall is erratic in its distribution hence the deficiency for optimum growth and development of plants. The mean total of the annual rainfall is 1,200mm (Olaniran, 2002).

The soil type in Ilorin is ferruginous tropical soil type existing on crystalline acidic rocks. The soil is uniform in terms of physical characteristics, the fertility of soils is variable and farming activities are enhanced in most parts of the study area (Oriola, 2006). The vegetation type found here is derived savannah with riparian forest along the river bank.

The general elevation of land on the western part varies from 273m to 364m (i.e. 900 to 1/200ft) above sea level. To the north of the western part of Ilorin exists an isolated hill known as Sobi Hill which is about 395m high above sea level. The geology of Ilorin is under-laid by pre-Cambrian basement complex rock of porphyritic granite type and also the undifferentiated type (Oyegun, 1985; Ajibade and Ojelola, 2004).

The drainage system of Ilorin is dendritic in pattern due to its characteristics. The most important river is Asa River which flows in south-northern direction. Asa river occupies a fairly wide valley and goes a long way to divide Ilorin into two parts namely the Eastern and the Western part. Some of the other rivers are Agba, Alalubosa, Okun, Osere and Aluko. Some of these rivers drain into River Niger or River Asa (Oyegun, 1985; Ajibade and Ojelola, 2004).

As of the 2006 census, Ilorin had a population of 777,667, making it the 6th largest city by population in Nigeria. Pottery is big business in Ilorin. The city has the biggest traditional pottery workshops in Nigeria.

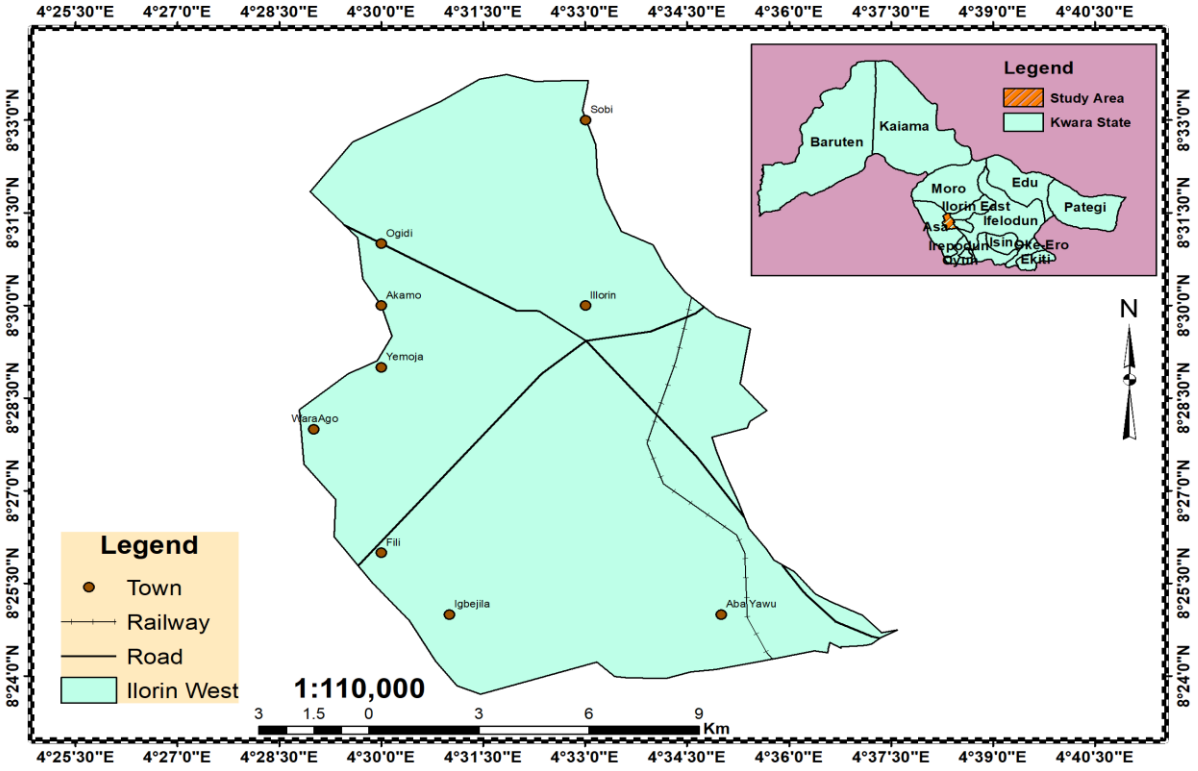

Figure 1: Ilorin West Map Showing Ilorin West Local Government Area (LGA) of Kwara State

Source: Adopted from Google Map (2018)

Materials and Methods

Eight registered bottled/packaged water companies out of the 12 listed registered bottled/packaged water companies in Ilorin West Local Government Area are still functioning. As a result, two (2) samples were each collected from eight (8) registered factories giving a total of 16 composite samples so as to avoid error (Table 1). Laboratory analysis was carried out by the

Standard Organization of Nigeria (SON). Water quality parameters (physicochemical and microbial) tests were conducted on the 16 samples. All samples were analyzed for the following physicochemical parameters: total dissolved solid, salinity, and suspended solid. The physicochemical analysis of the water was carried out in accordance to Standard Analytical methods and was compared to the Nigeria Industrial Standard (NIS). Mean, range, standard deviation, coefficient of variance, and t-test were used for the data summarization and analysis.

Table 1: Names of water packaging companies in Ilorin West (LGA) Kwara State

Name of Companies	Location
Peace Standard Pharmaceutical	Adewole
Seap	Olorunsogo
Tuyil Pharmaceutical	New Yidi road
Newsong Glory Ventures	New Yidi road
Remtosh Nigeria Limited	New Yidi road
Leapson Water	Airport
Alhikmah Water	Adewole
De-callif Investment Nig. Ltd	Agbo-oba

Table 2: Laboratory Analysis of Water Quality by Standard Organisation of Nigeria

S/N	Parameters	Laboratory Methods by SON
1	Colour	Colorimetric
2	Odour	Organoleptic
3	Taste	Organoleptic
4	Temperature	Thermometer
5	pH	Electrometric
6	Turbidity	Turbidity
7	Aluminium	AAS
8	Arsenic	AAS
9	Barium	AAS
10	Cadmium	AAS
11	Chloride	Argentometric
12	Chromium	Colorimetric
13	Conductivity	Multimeter
14	Copper	AAS
15	Fluoride	Colorimetric
16	Hardness	AAS
17	Iron	AAS
18	Lead	AAS
19	Magnesium	AAS
20	Manganese	AAS
21	Nickel	AAS
22	Nitrate	Colorimetric
23	Nitrite	Colorimetric
24	Sodium	AAS
25	Zinc	AAS
26	Total dissolved solid	Gravimetric
27	Coliform	Filtration
28	Clostridium perfringes	Filtration
29	E. *coli*	Filtration
30	Klebsiellaaerogenes	Filtration
31	Faecal streptococcus	Filtration
32	Salmonella shegalla	Filtration
33	S. aeurus	Filtration
34	Yeast/mould	Filtration

Source: Standards Organization of Nigeria (SON)

Table 3: Essential Requirements for bottled/packaged drinking water by NIS

Physical/Organoleptic		
1.	Taste	Unobjectionable
2.	Odour	Unobjectionable
3.	Colour (TCU[a)]	3.0
4.	Turbidity(NTU[b])	5.0
5.	Ph	6.5-8.5
6.	Conductivity	1000µS/cm
Chemical		
7.	Iron	0.3mg/L
8.	Nitrate	10mg/L
9.	Aluminium	0.002mg/L
10.	Chloride	100mg/L
11.	Fluoride	1.0mg/L
12.	Copper	1.0mg/L
13.	Nitrite	0.02mg/L
14.	Manganese	0.1mg/L
15.	Magnesium	2.0mg/L
16.	Sodium	100mg/L
17.	Zinc	5.0mg/L
18.	Total Dissolved Solids	500mg/L
19.	Hardness (as $CaCO_3$)	100mg/L
20.	Hydrogen Sulphide	0.01mg/L
21.	Sulphate	100mg/L
Microbial		
22.	*Clostridium perfringnes*	0
23.	*E.Coli*	0
24.	*Faecal Streptococci*	0
25.	*Pseudomonas Aeroginosa*	0
26.	*Coliform*	0
27.	*Yeast and Mould*	0

Source: Standards Organization of Nigeria (SON)

RESULTS AND DISCUSSION

Tuyil Pharmaceuticals, Newsong Ventures, Remtosh Nig. Ltd., Alhikmah Water and Seap have colourless water while Peace Water (1.1), Leap Ventures (1.5) and Bluemist Water (1.5) have coloured water (Table 4). The mean colour value is 0.51TCU with a standard deviation of 0.72 and a coefficient of variation of 141%, meaning that the color of water in the area is heterogeneous. This implies that the color of water varies in occurrence pointing to the fact that it is highly variable. Therefore, there is need for close monitoring as the color of water is a major indicator of the state of water. Furthermore, all the packaged water in the area are odorless and tasteless. In the same vein, temperature of packaged water in the area ranged from 21°C (Tuyil pharmaceuticals) to 31°C (Remtosh Nig. Ltd). The mean temperature of packaged water in the area is 26.6°C with a standard deviation of 3.93 and a coefficient of variation of 14.8%, meaning that temperature of packaged water in the area is homogeneous.

Table 4: Physical Characteristics

Variables	Peace Water	Tuyil Pharm	Newsong Ventures	Remtosh Nig Ltd	Seap	Alhikmah Water	Leapson Ventures	Bluemist Water	**Mean**	**STD**	**CV%**
Colour	1.1	0	0	0	0	0	1.5	1.5	**0.51**	**0.72**	**141**
Odour	0	0	0	0	0	0	0	0	**0**	**0**	**0**
Taste	0	0	0	0	0	0	0	0	**0**	**0**	**0**
Temp	30.0	21	25	31	25.7	29.2	29.7	21.5	**26.6**	**3.93**	**14.8**

Source: Author's Computation, (2018)

All the chemical water parameters presented a heterogeneous pattern with high coefficient of variation except for pH, with a mean range from 6.55 (Remtosh Nig. Ltd) to 7.95 (Newsong Ventures). The mean pH is 7.15 with a standard deviation of 0.42 and a coefficient of variation of 5.87% implying that pH of water in the area is homogeneous. The implication is that these parameters vary in the nature of occurrence in the packaged water, pointing to the fact that the water chemistry properties are highly variable and according to Ifabiyi (2008), suggests that there is a need for close monitoring of chemical parameters so that the consumers of packaged water do not get affected by water-related diseases. Aluminum, arsenic, barium, cadmium, chromium, lead and nickel were absent in packaged water samples (Table 5).

Table 5: Chemical Characteristics

Variables		Peace Water	Tuyil Pharm	Newsong Ventures	Remtosh Nig Ltd	Seap	Alhikmah Water	Leapson Ventures	Bluemist Water	**Mean**	**STD**	**CV%**
1.	Ph	7.0	7.1	7.95	6.55	7.15	6.94	7.04	7.5	**7.15**	**0.42**	**5.87**
2.	Turbidity	1.9	0	0	0	0	0	1.0	0.6	**0.44**	**0.70**	**159**
3.	Aluminum	0	0	0	0	0	0	0	0	**0**	**0**	**0**
4.	Arsenic	0	0	0	0	0	0	0	0	**0**	**0**	**0**
5.	Barium	0	0	0	0	0	0	0	0	**0**	**0**	**0**
6.	Cadmium	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7.	Chlorine	13.0	15	6.3	0.2	1.0	5.8	26.1	26.1	**10.0**	**10.7**	**107**
8.	Chromium	0	0	0	0	0	0	0	0	**0**	**0**	**0**
9.	Cond	90	68	101.2	0	30.5	106.5	399	186	**122.6**	**124.6**	**101.6**
10.	Copper	0.80	0.03	0.09	0	0	0	0	0	**0.12**	**0.28**	**233.3**
11.	Fluoride	0.98	0	0	0	7.7	0	0.05	0.01	**1.09**	**2.69**	**246.7**
12.	Hardness	36.1	6	21.5	10.0	0	26.5	101	15	**27.0**	**32.1**	**118.9**
13.	Iron	0.003	0	0.002	0	0	0	0.05	0	**0.007**	**0.02**	**285.7**
14.	Lead	0	0	0	0	0	0	0	0	**0**	**0**	**0**

15.	Magnesium	0	0.04	0.26	0.1	0	0.5	7.9	0.03	**1.10**	**2.75**	**250**
16.	Manganese	0	0	0.01	0	0	0	0	0	**0.001**	**0.004**	**400**
17.	Nickel	0	0	0	0	0	0	0	0	**0**	**0**	**0**
18.	Nitrate	16.67	0.28	0.5	0	0	0.2	3.6	0.5	**2.72**	**5.76**	**211.7**
19.	Nitrite	0.006	0	0	0	0	0	0.02	0	**0.004**	**0.007**	**175**
20.	Sodium	24.03	8	0	0	0	0	0	0	**4.0**	**8.56**	**214**
21.	Zinc	0	0.02	0.07	0	0	0	0.05	0	**0.018**	**0.027**	**150**
22.	TDS	40	22	60.7	0	18.3	63.9	239.4	92	**67.0**	**75.6**	**112.8**

Source: Author's Computation, 2018

Table 6: Microbial Characteristics

Variables	Peace Water	Tuyil Pharm	Newsong Ventures	Remtosh Nig Ltd	Seap	Alhikmah Water	Leapson Ventures	Bluemist Water	**Mean**	**STD**	**CV%**
1. Coliform C.	0	0	0	0	0	0	3	0	**0.375**	**1.06**	**282.7**
2. Clostridium	0	0	0	0	0	0	0	0	**0**	**0**	**0**
3. E.Coli	0	0	0	0	0	0	0	0	**0**	**0**	**0**
4. Klebsiella	0	0	0	0	0	0	0	0	**0**	**0**	**0**
5. Salmonella	0	0	0	0	0	0	0	0	**0**	**0**	**0**
6. S. Aeurus	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7. Yeast	0	0	0	0	0	0	0	0	**0**	**0**	**0**

STD: Standard deviation

CV: Coefficient of variance

Source: Author's Computation, 2018

All the packaged water do not have any content of clostridium, e.coli, klebsiella, salmonella, s.aeurus and yeast in them (Table 6). In the same vein, all water samples do not have coliform count in them except Leapson Water that has a 3cgu/l content. This result shows that packaged water in the area do not have biological contaminants except that of Leapson Water. Thus, proper water purification should be done by Leapson Water Company to avoid cases of typhoid, diarrhea among others.

Comparison of Packaged Water Quality to NIS Standard

The water quality parameters that were within the permissible limit of NIS standard are colour, pH, turbidity, conductivity, iron, magnesium, manganese, nitrate, nitrite, sodium, zinc and total dissolved solids (Figure 2-13) for all the companies.

On the other hand, temperature, chloride, fluoride, total hardness and coliform count (Fig 14-19) did not fall within the permissible limit of the NIS standard for all the water companies. There was no significant difference between the water quality parameters and the NIS standard with P value (1.7) > 0.05 (Table 7). This implies that all the water samples from the packaged water factories are within the NIS standard for packaged water and suitable for consumption.

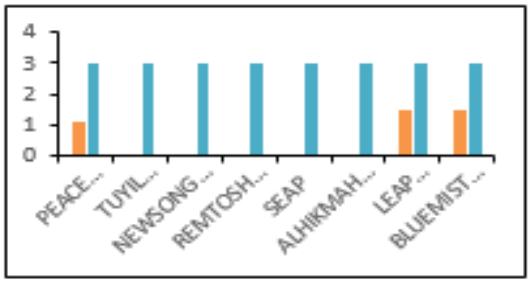

Figure 2: Colour of Water

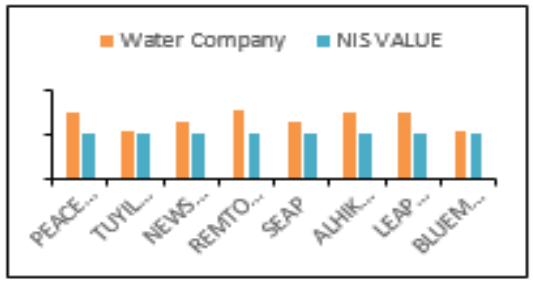

Figure 3: Temperature of Water

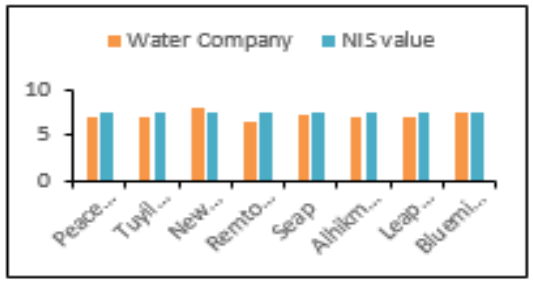

Figure 4: pH of Water

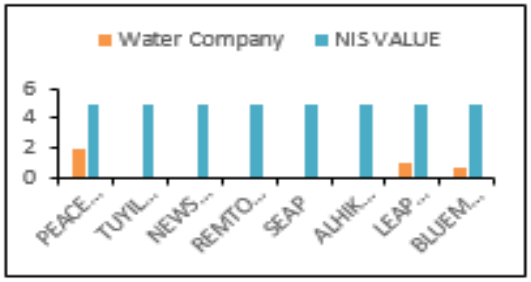

Figure 5: Turbidity of Water

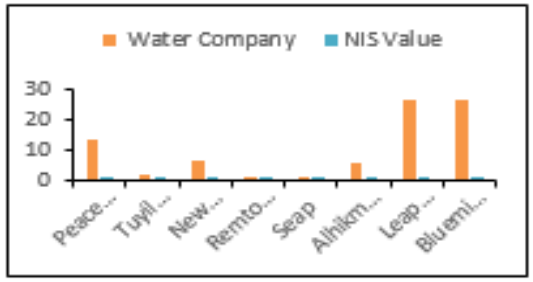

Figure 6: Chloride in Water

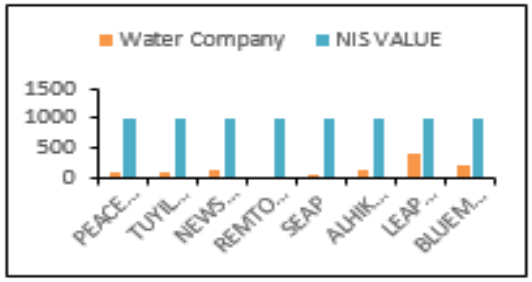

Figure 7: Conductivity of Water

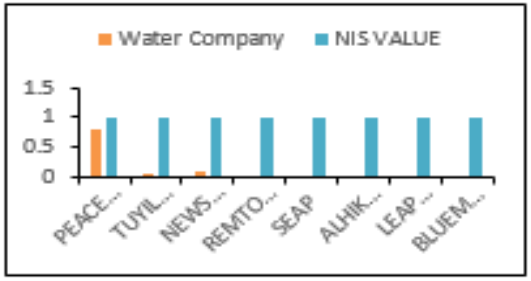

Figure 8: Copper of Water

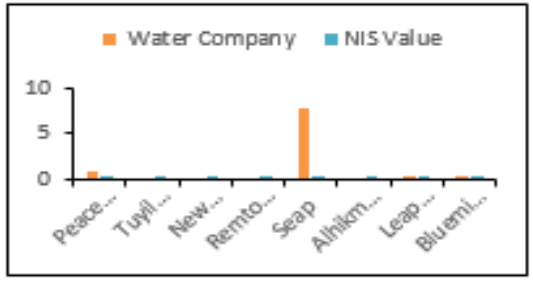

Figure 9: Fluoride in Water

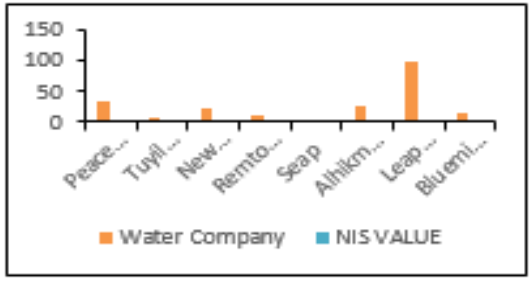

Figure 10: Total Hardness of Water

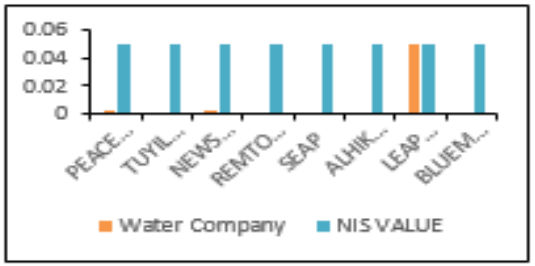

Figure 11: Iron of Water

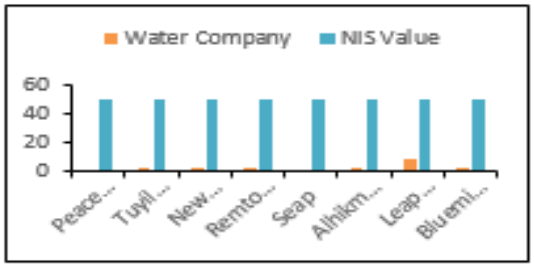

Figure 12: Magnesium in Water

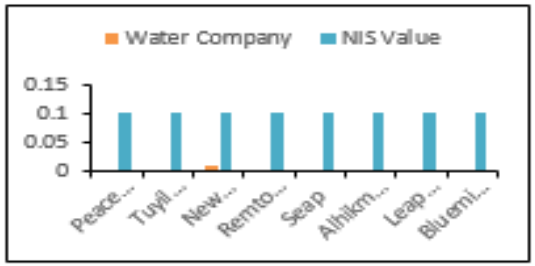

Figure 13: Manganese in Water

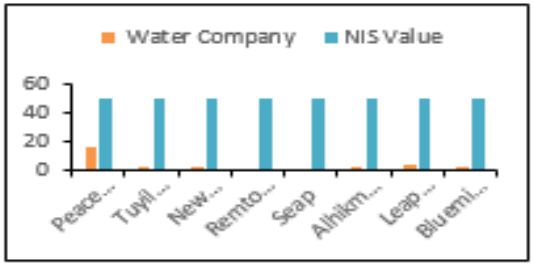

Figure 14: Nitrate in water

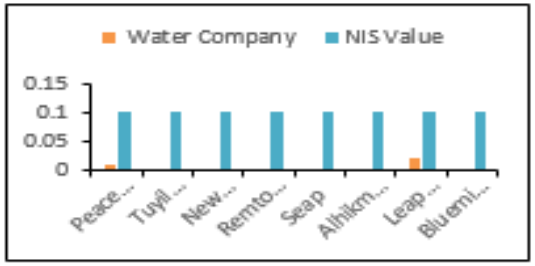

Figure 15: Nitrite in Water

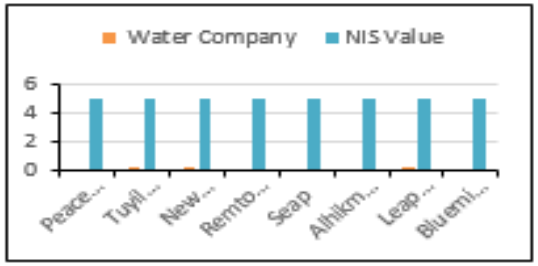

Figure 16: Sodium in Water

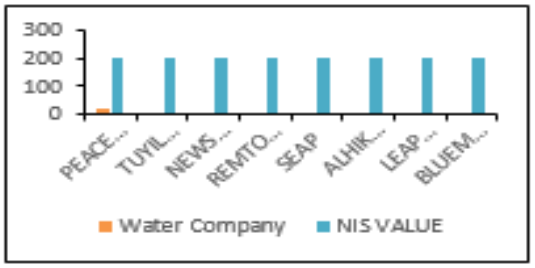

Figure 17: Zinc in Water

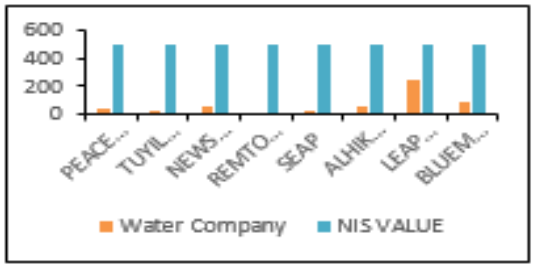

Figure 18: Total Dissolved Solids

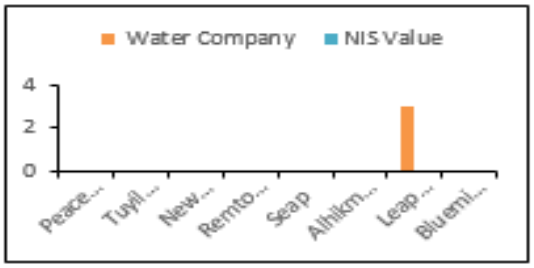

Figure 19: Coliform Count in Water

Table 4.4: Comparison with NIS Values

	Mean	Std. Deviation	Std.Error Mean	95% Confidence Interval of the Difference		T	Df	T-critical
				Lower	Upper			
Peace – NIS	-87.80117	234.78520	55.33940	-204.55710	28.95476	-1.587	17	1.740
Tuyil – NIS	-94.14111	240.06522	56.58392	-213.52274	25.24051	-1.664	17	1.740
Newson – NIS	-89.91267	230.19304	54.25702	-204.38497	24.55964	-1.657	17	1.740
Remotosh - NIS	-99.67556	256.26665	60.40263	-227.11396	27.76285	-1.650	17	1.740
Seap – NIS	-97.31444	248.12900	58.48457	-220.70609	26.07721	-1.664	17	1.740
Alhikmah - NIS	-89.02611	229.02142	53.98087	-202.91579	24.86356	-1.649	17	1.740
Leap – NIS	-56.81111	158.28678	37.30855	-135.52528	21.90305	-1.523	17	1.740
Bluemist – NIS	-82.84833	210.23874	49.55375	-187.39760	21.70093	-1.672	17	1.740

Source: Author's Computation, 2018

In conclusion, there was variation in the physicochemical characteristics among the sampled packaged water brands but there was no significant difference between the sampled packaged water brands compared to the NIS standard for drinking water. The study therefore recommends that the safety of packaged drinking water should be further ensured through comprehensive regulatory programs at both the federal and state levels. NAFDAC regulations for packaged water should be protective of public health and there should be continuous adoption of packaged water quality standards. Testing of market samples approach will enable the detection of substandard packaged water in the study area.

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