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Assessment of Water Quality of Commonly Consumed Packaged Water in Port Harcourt Metropolis

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Abstract
Water samples from different water packaging companies in Port Harcourt metropolis were analyzed for drinking purposes. Eleven brands of packaged water produced in Port Harcourt characterized into big (A - D) and small (E - K) companies were screened for quality characteristics. Sachets and bottled water samples were collected from production plants on the day of production. Analysis was conducted for six weeks in order to determine the deterioration rate with time. The results obtained showed that the physical, chemical and microbiological characteristics of all the water brands met the existing drinking water standards, except for pH, on the day of production for all companies and at six weeks for only two big companies (A and B) and four small companies (E, F, H and K). The results of water quality index (1.24 – 38.88) indicated that all brands were fit for consumption with sample C having the best quality (1.24) while E had the least quality (38.88). A significant difference was observed between the water quality of: bottled waters from the big companies, bottled waters from the small companies, sachet waters from the small companies, bottled and sachet waters from E-H companies, and bottled waters from big and small companies. It was concluded that all tested packaged water brands consumed in Port Harcourt metropolis were safe for drinking within the first six weeks of production. However, there is need to investigate the shelf life beyond six weeks to determine the actual shelf life.

Keywords: *Drinking water quality, Water packaging companies, Bottled water, Sachet water, Port Harcourt*

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1. Introduction

Water is an essential component for life on Earth, and totally dominates the chemical composition of all organisms. It plays a vital role in the body metabolism and proper functioning of cells (Taiwo et al., 2010). The quality of consumed water is a prevailing environmental determinant of health and a good foundation for prevention and control of water related diseases (Chukwuma et al., 2018). Packaged water consumption has been steadily growing in Port Harcourt metropolis. The consumption of packaged water in the world increases by an average of 12% each year, in spite of its high price compared to tap water (Rosemann, 2005). Consumers may have various reasons for purchasing packaged drinking water, including taste, fashion, or convenience but for many consumers, safety and potential health benefits are important considerations because they believe packaged water is safer than tap water.

In recent times, public concerns over the quality of drinking water have grown considerably. These concerns are as a result of increased awareness on different episodes of waterborne disease outbreaks and environmental pollution (Anadu and Harding, 2000). According to Oyegun (1983), a large number of miseries and deaths occur due to infectious diseases which are related to open water supplies in the tropical developing countries. In developing countries, there are so many people exposed to unsafe drinking water, which resulted in so many waterborne disease infections.

Packaged water companies have been on the increase to meet the demand of the populace. The most compelling issue is the fact that consumers are shifting to packaged water without ascertaining if these companies are producing potable water. Water can be described as potable if it complies with certain physical, chemical and microbiological standards, which are designed to ensure that the water is safe for drinking (Kurup et al., 2010).

Most packaged water companies do not follow the laid down standards in production such as proper treatment and registration of brand with the appropriate authority such as the National Agency for Food and Drug Administration and Control (NAFDAC). Some go as far as producing in dirty environments and using fake NAFDAC number. It is therefore important to determine the quality of the packaged water and also ascertain if they meet international and local standards. Hence, a comprehensive analysis of packaged water available in Port Harcourt metropolis will guide consumers' choice on what brand of packaged water is safe for consumption and will encourage monitoring bodies to embark on timely routine inspection of water companies, frequent safety testing and sanction of defaulters.

2. Materials and methods

2.1 Study area

The city of Port Harcourt (latitude 4.84217°N and longitude 7.03361°E) is the capital of Rivers State and the hub of the oil and gas industry in the Niger Delta as well as the most populated city in the South-South geopolitical zone in Nigeria. As of 2016, the Port Harcourt urban area has an estimated population of 1,865,000 inhabitants, up from 1,382,592 as of 2006. This growth in population has outstripped infrastructural development, including public water supplies. Most residents, commercial establishments and industries rely on shallow water wells for self-supplies (borehole). Leachates from unregulated garbage dumps are also a constant source of nutrient loading to groundwater (Abimbola et al., 2002). Pathogens, elevated cadmium and lead levels have thus been reported from shallow groundwater (Akpoborie et al., 2000; Ejechi et al., 2007). Traces of benzene and toluene have also been reported from dug wells in the vicinity of a refinery and industrial chemical complex (Akpoborie et al., 2008). Packaged water is therefore the preferred choice of drinking water by consumers in Port Harcourt, and it is used in homes, schools, offices, hotels, various categories of eateries and fast-food outlets, and sophisticated restaurants. The map of Port Harcourt showing locations of the selected water companies is presented in Fig. 1.

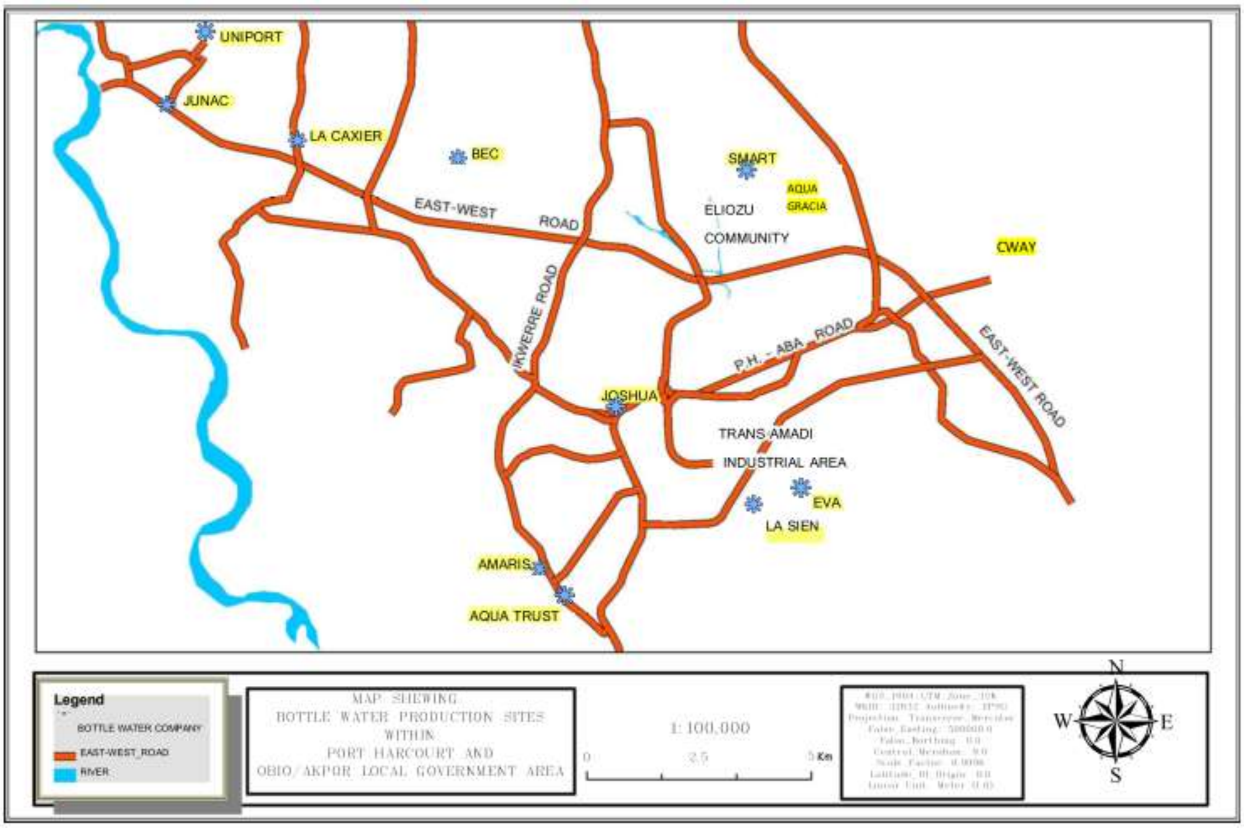

Fig. 1: Map of Port Harcourt showing locations of selected water companies

2.2 Determination of sample size

A representative sample size of eleven (11) packaged water companies was determined for this research using Equation (1) with a 70% confidence level (Yamane, 1967):

$$n = \frac{N}{1 + N(e)^2} \quad (1)$$

where n is the sample size, N is the population size which is 118 registered table water companies in Port Harcourt (NAFDAC, 2017) and e is the level of precision which is (100 -70) % or 30% or 0.3.

2.3 Sample collection

Eleven different brands of bottled water and four different brands of sachet water samples with National Agency for Food and Drug Administration and Control (NAFDAC) certification were randomly collected in different parts of Port Harcourt metropolis from eleven randomly selected packaged water companies as shown in Table 1. One bag of available brand of sachet water containing twenty sachets and one carton of each brand of bottled water containing twelve bottles were procured at the packaged water companies on the day of production and taken to the laboratory for analysis. The samples were stored at room temperature. The physico-chemical and microbial quality of the water samples were determined at intervals of two weeks up to a period of six consecutive weeks. The selected companies for the analysis were grouped into big and small companies. Big companies consisted of companies whose brand name is generally accepted by the public while small companies consisted of companies that are just springing up. The samples were grouped as follows: A – D as Big companies and E – K as Small Companies. E_s, F_s, G_s and H_s represent available sachet water samples of companies E, F, G and H respectively while A_b to K_b represent bottled water samples of companies A to K, respectively.

Table 1: Collected water samples

Packaged water company	Code	Bottled water sample	Sachet water sample
Big			
Eva Bottled Water	A	A_b	N/A
Joshua Bottled Water	B	B_b	N/A
Cway Bottled Water	C	C_b	N/A
La Sien Bottled Water	D	D_b	N/A
Small			
Smart Bottled Water	E	E_b	E_s
UNIPORT Bottled Water	F	F_b	F_s
Junac Bottled Water	G	G_b	G_s
La Caxier Bottled Water	H	H_b	H_s
Amaris Bottled Water	I	I_b	N/A
Aqua Gracia Bottled Water	J	J_b	N/A
Aqua Trust Bottle Water	K	K_b	N/A

N/A – Not Available

2.4 Sample analysis

At the laboratory, one sample each from each group and brand was randomly selected for physical examination. Samples were thereafter subjected to bacteriological and physicochemical analyses. Electrical conductivity and total dissolved solids (TDS) were measured with the HACH conductivity/TDS meter. The pH of each sample was measured with the Schott Gerate model pH meter. Nitrate concentration was determined with the HACH Spectro-Photometer while turbidity was measured using the HACH 2100 AN Turbidimeter. Major ions (Ca^{2+}, Mg^{2+}, NO^{3-}) and heavy metals (Pb^{2+} and Cd^{2+}) were determined with the appropriate Titrimetry, Flame Photometric and Atomic Absorption Spectrometric methods (APHA, 1998). In order to determine the presence of total coliform, 100 ml of each water sample was passed through a membrane filter consisting of uniform pore diameter of 0.45 nm. The membrane filter was then placed in a petri-dish containing Mac-Conkey Agar and Eosin-Methylene Blue Agar in duplicate with the grid side up and incubated at 35 and 45°C for 18 - 24 hours respectively so as to recover total coliform where present. Bacteria colonies if present were counted and expressed as numbers of coliform per 100 ml of water.

2.5 Water quality index calculation

From the laboratory analysis result, water quality index (WQI) was calculated for the different samples using Equation (2) (Boah et al., 2015) and compared with each other as well as with local and international standards.

$$WQI = \frac{\sum q_i w_i}{\sum w_i} \quad (2)$$

where w_i is the relative weight of the i^{th} parameter and qi is the water quality rating of the i^{th}

parameter. The unit weight (w_i) of the various water quality parameters is inversely proportional to the recommended standards for the corresponding parameters. The value of q_i was calculated using Equation (3) (Boah et al., 2015).

$$q_i = \frac{(V_i - V_{id})}{(S_i - V_{id})} \times 100 \quad (3)$$

where V_i is the observed value of the i^{th} parameter, S_i is the standard permissible value of the i^{th} parameter and V_{id} is the ideal value of the i^{th} parameter in pure water.

For the calculation of WQI, the water quality parameters were selected based on their direct involvement in the deteriorating water quality for human consumption. The selected parameters were pH, Turbidity, Electrical conductivity (EC), Total dissolved solids (TDS), Ca^{2+} and NO_3^-. The standards for drinking water, recommended by World Health Organisation (WHO) and Standards Organisation of Nigeria (SON) were considered for the computation of q_i and W_i. The standard values of water quality parameters and their corresponding ideal values and unit weights are given in Table 2. The suitability of WQI values for human consumption is summarized in Table 3.

Table 2: Standard values of water quality parameters and their corresponding ideal values and unit weights (WHO, 2006; SON, 2007)

Parameters	**S_i**	**Recommending Agency for S_i**	**Ideal Value (V_{id})**	**K**	**W_i**
pH	8.5	WHO/SON	7	2.78912061	0.328132
EC	300	WHO	0	2.78912061	0.009297
TDS	500	WHO/SON	0	2.78912061	0.005578
Turbidity	5	WHO/SON	0	2.78912061	0.557824
NO_3^-	45	WHO	0	2.78912061	0.06198
Ca^{2+}	75	WHO	0	2.78912061	0.037188

K is the proportionality constant.

Table 3: WQI range and status

WQI	**Status**
0 – 25	Excellent
25 – 50	Good
51 – 75	Fair
76 – 100	Poor
101 – 150	Very poor
Above 150	Unfit for drinking

2.6 Statistical analysis of data

Analysis of variance (ANOVA) was used to check for significant difference among the studied packaged waters. Two-way and one-way ANOVA were employed for the different comparisons. Comparison among big companies bottled water, small companies bottled water and small companies' sachet water used a two-way ANOVA while comparison between bottled and sachet water of a company as well as between the average WQI big companies bottled water and small companies bottled water used a one-way ANOVA. The level of significance employed was 0.05. Significance was established when p-value is less than 0.05.

2.7 Plot-extracted WQI predicting model

A model predicting the WQI for each selected packaged water at any time was obtained as a linear equation from the plot of WQI against time for each package water sample with the general form as shown in Equation (4).

$$y = ax + b \quad (4)$$

where y = WQI, x = time, and a and b are constants

3. Results and discussion

3.1 Water quality parameters

Results of laboratory analyses are presented in Tables 4, 5, 6 and 7. The WHO guidelines for drinking water quality and the maximum permitted limits (MPLs) specified in SON are used for comparison. From the results obtained, all samples did not meet the pH standard of 6.5 – 8.5 on the day of production. However, the samples met the standard at six weeks except for samples A, B, E, F, H and K. Similar change in pH with time has been reported by Ruma et al. (2014) and Engwa et al. (2015) and was explained to be due to water container being permeable to carbon dioxide. For all water samples, nitrate concentration was found to be below the WHO and SON maximum permissible limits of 45 and 50mg/l, respectively. Similarly, calcium, turbidity, lead, cadmium, magnesium and total coliform were found to be below the WHO and SON maximum permissible limit of 75mg/l, 5 NTU, 0.01 mg/l, 0.003 mg/l, 0.2 mg/l and 10 cfu/ml, respectively.

The results obtained from the analysis of the different packaged water samples for pH, Electrical Conductivity (EC), Total Dissolved Solid (TDS), Calcium (Ca^{2+}) and Nitrate (NO_3^-) varied but those of Magnesium, Turbidity, Lead, Cadmium and Total Coliform were constant throughout the duration of the analysis. Prolonged storage of the packaged water samples caused an increase in pH. Similar observation has been reported by Akinde et al. (2011). Ruma et al. (2014) also noticed the same trend with sachet water in which values of EC, Ca^{2+} and TDS varied with time. Though values of EC, TDS, Ca^{2+} and NO_3^- varied upward, none was above the respective maximum permissible limits. Thus, the results obtained show that all packaged water samples were good for consumption. Similar finding was reported by Chukwuma et al. (2018) and Akpoborie and Ehwarimo (2012) for all sachet and bottled water sold in the University of Port Harcourt premises and Warri Metropolis, respectively.

Table 4: Water quality parameters of packaged waters on the day of production

Sample	pH	EC (µS/cm)	TDS (mg/l)	T (NTU)	NO_3^- (mg/l)	Ca^{2+} (mg/l)	Pb^{2+} (mg/l)	Cd^{2+} (mg/l)	Mg^{2+} (mg/l)	TC
A_b	5.71	135.2	67.6	0.05	2.18	0.751	<0.012	<0.0028	<0.0018	<1.8
B_b	6.23	36.6	18.3	0.05	0.91	0.935	<0.012	<0.0028	<0.0018	<1.8
C_b	6.46	2.29	1.44	0.05	0.06	<0.0042	<0.012	<0.0028	<0.0018	<1.8
D_b	5.87	37.0	18.5	0.05	1.21	<0.0042	<0.012	<0.0028	<0.0018	<1.8
E_b	5.26	22.8	11.8	0.05	1.30	<0.0042	<0.012	<0.0028	<0.0018	<1.8
E_s	5.09	25.5	12.8	0.05	1.08	<0.0042	<0.012	<0.0028	<0.0018	<1.8
F_b	5.57	79.5	39.8	0.05	0.11	<0.0042	<0.012	<0.0028	<0.0018	<1.8
F_s	5.41	22.1	11.1	0.05	0.01	<0.0042	<0.012	<0.0028	<0.0018	<1.8
G_b	6.02	164.0	81.9	0.05	0.13	<0.0042	<0.012	<0.0028	<0.0018	<1.8
G_s	6.21	153.0	76.5	0.05	0.11	<0.0042	<0.012	<0.0028	<0.0018	<1.8
H_b	5.34	23.5	11.7	0.05	0.5	0.513	<0.012	<0.0028	<0.0018	<1.8
H_s	5.17	18.50	9.28	0.05	0.07	0.12	<0.012	<0.0028	<0.0018	<1.8
I_b	6.25	196.5	98.5	0.05	0.2	<0.0042	<0.012	<0.0028	<0.0018	<1.8
J_b	5.65	33.6	16.8	0.05	0.39	<0.0042	<0.012	<0.0028	<0.0018	<1.8
K_b	5.78	114.1	57.0	0.05	2.12	4.80	<0.012	<0.0028	<0.0018	<1.8

T is Turbidity while TC is Total Coliform.

Table 5: Water quality parameters of packaged waters two weeks after production

Sample	**pH**	**EC (µS/cm)**	**TDS (mg/l)**	**T (NTU)**	NO_3^- **(mg/l)**	Ca^{2+} **(mg/l)**	Pb^{2+} **(mg/l)**	Cd^{2+} **(mg/l)**	Mg^{2+} **(mg/l)**	**TC**
A_b	5.69	138.1	68.3	0.05	2.34	1.02	<0.012	<0.0028	<0.0018	<1.8
B_b	6.20	34.8	17.4	0.05	0.924	1.73	<0.012	<0.0028	<0.0018	<1.8
C_b	6.45	2.49	1.40	0.05	0.075	<0.0042	<0.012	<0.0028	<0.0018	<1.8
D_b	5.80	38.1	18.9	0.05	1.26	<0.0042	<0.012	<0.0028	<0.0018	<1.8
E_b	5.21	23.0	11.7	0.05	1.34	0.513	<0.012	<0.0028	<0.0018	<1.8
E_s	5.08	23.4	11.4	0.05	1.09	<0.0042	<0.012	<0.0028	<0.0018	<1.8
F_b	5.55	60.2	27.6	0.05	0.130	0.567	<0.012	<0.0028	<0.0018	<1.8
F_s	5.40	21.3	10.9	0.05	0.006	<0.0042	<0.012	<0.0028	<0.0018	<1.8
G_b	6.02	173.1	83.7	0.05	0.132	0.3111	<0.012	<0.0028	<0.0018	<1.8
G_s	6.17	152.0	75.4	0.05	0.108	<0.0042	<0.012	<0.0028	<0.0018	<1.8
H_b	5.33	19.04	9.6	0.05	0.049	0.876	<0.012	<0.0028	<0.0018	<1.8
H_s	5.14	17.6	8.93	0.05	0.073	0.231	<0.012	<0.0028	<0.0018	<1.8
I_b	6.25	200	100.6	0.05	0.254	0.0065	<0.012	<0.0028	<0.0018	<1.8
J_b	5.60	34.7	17.2	0.05	0.403	<0.0042	<0.012	<0.0028	<0.0018	<1.8
K_b	5.72	123	58.3	0.05	2.19	3.15	<0.012	<0.0028	<0.0018	<1.8

Table 6: Water quality parameters of packaged waters four weeks after production

Sample	pH	EC (μS/cm)	TDS (mg/l)	T (NTU)	NO_3^- (mg/l)	Ca^{2+} (mg/l)	Pb^{2+} (mg/l)	Cd^{2+} (mg/l)	Mg^{2+} (mg/l)	TC
A_b	5.63	141.1	70.5	0.05	2.48	2.08	<0.012	<0.0028	<0.0018	<1.8
B_b	6.19	33.0	16.5	0.05	0.962	2.54	<0.012	<0.0028	<0.0018	<1.8
C_b	6.45	2.64	1.35	0.05	0.092	<0.0042	<0.012	<0.0028	<0.0018	<1.8
D_b	5.80	38.8	19.4	0.05	1.30	0.005	<0.012	<0.0028	<0.0018	<1.8
E_b	5.20	23.2	11.6	0.05	1.37	0.083	<0.012	<0.0028	<0.0018	<1.8
E_s	5.07	21.1	10.6	0.05	1.10	<0.0042	<0.012	<0.0028	<0.0018	<1.8
F_b	5.50	37.5	18.7	0.05	0.143	0.745	<0.012	<0.0028	<0.0018	<1.8
F_s	5.40	20.8	10.5	0.05	0.007	<0.0042	<0.012	<0.0028	<0.0018	<1.8
G_b	6.58	170.0	85.0	0.05	0.143	0.436	<0.012	<0.0028	<0.0018	<1.8
G_s	6.13	150	75	0.05	0.109	<0.0042	<0.012	<0.0028	<0.0018	<1.8
H_b	5.24	14.62	7.3	0.05	0.058	1.82	<0.012	<0.0028	<0.0018	<1.8
H_s	5.11	16.03	8.01	0.05	0.075	0.380	<0.012	<0.0028	<0.0018	<1.8
I_b	6.23	203	102	0.05	0.246	0.016	<0.012	<0.0028	<0.0018	<1.8
J_b	5.54	35.8	17.9	0.05	0.416	<0.0042	<0.012	<0.0028	<0.0018	<1.8
K_b	5.70	119.2	59.6	0.05	2.24	2.76	<0.012	<0.0028	<0.0018	<1.8

Table 7: Water quality parameters of packaged waters six weeks after production

Sample	pH	EC (μS/cm)	TDS (mg/l)	T (NTU)	NO_3^- (mg/l)	Ca^{2+} (mg/l)	Pb^{2+} (mg/l)	Cd^{2+} (mg/l)	Mg^{2+} (mg/l)	TC
A_b	5.59	145.6	73.2	0.05	2.78	3.20	<0.012	<0.0028	<0.0018	<1.8
B_b	6.13	28.90	15.4	0.05	0.988	2.78	<0.012	<0.0028	<0.0018	<1.8
C_b	6.41	2.94	1.27	0.05	0.107	<0.0042	<0.012	<0.0028	<0.0018	<1.8
D_b	5.73	39.4	20.1	0.05	1.39	0.006	<0.012	<0.0028	<0.0018	<1.8
E_b	5.15	25.0	11.4	0.05	1.45	0.12	<0.012	<0.0028	<0.0018	<1.8
E_s	5.01	20.4	10.2	0.05	1.12	<0.0042	<0.012	<0.0028	<0.0018	<1.8
F_b	5.45	30.5	16.3	0.05	0.177	0.876	<0.012	<0.0028	<0.0018	<1.8
F_s	5.39	18.88	10.0	0.05	0.009	<0.0042	<0.012	<0.0028	<0.0018	<1.8
G_b	5.92	173.3	89.4	0.05	0.156	0.543	<0.012	<0.0028	<0.0018	<1.8
G_s	6.03	148.9	75	0.05	0.203	<0.0042	<0.012	<0.0028	<0.0018	<1.8
H_b	5.25	13.8	6.12	0.05	0.061	1.90	<0.012	<0.0028	<0.0018	<1.8
H_s	5.11	15.47	8.0	0.05	0.081	0.401	<0.012	<0.0028	<0.0018	<1.8
I_b	6.01	206	106.3	0.05	0.295	0.023	<0.012	<0.0028	<0.0018	<1.8
J_b	5.52	37.5	19.1	0.05	0.433	<0.0042	<0.012	<0.0028	<0.0018	<1.8
K_b	5.71	122.5	61.5	0.05	2.35	0.987	<0.012	<0.0028	<0.0018	<1.8

3.2 Water quality index

The calculated WQI for all selected packaged water samples is presented in Table 8. The WQI for day of production (DoP) shows that samples were within the range of 12.39 – 42.58 which falls within 'Excellent' and 'Good' on the water quality range and status. Generally, WQI varied with time during the period of analysis. Similar observation has been reported by Popoola et al. (2007), and has been explained to result from the development of suspended particles likely due to the activities of microorganisms whose populations start to build up after few days of water storage. Sample C_b has the best water quality while E_s has the worst water quality. In general, all samples are fit for drinking because they are within the limit of 'Excellent' and 'Good' in the water quality index status.

Table 8: WQI for all packaged water samples

Sample	WQI (DoP)	WQI (Wk 2)	WQI (Wk 4)	WQI (Wk 6)
A_b	29.61	30.09	31.49	32.48
B_b	17.71	18.40	18.66	19.97
C_b	12.39	12.61	12.61	13.49

D_b	25.58	27.12	27.13	28.68
E_b	38.88	40.01	40.21	42.32
E_s	42.58	42.79	43.01	44.32
F_b	32.15	32.54	33.56	34.65
F_s	35.42	35.64	35.64	35.85
G_b	22.61	22.66	23.10	24.87
G_s	18.41	19.28	20.15	22.35
H_b	36.99	37.21	39.21	38.99
H_s	40.67	41.33	41.33	41.99
I_b	17.71	17.73	18.18	18.86
J_b	30.27	31.37	32.68	33.13
K_b	28.19	29.46	29.88	29.55

DoP – Day of production

3.3 Comparison of studied packaged waters

Analysis of variance (ANOVA) was used to check for significant difference among the studied packaged waters. A significant difference was observed among the bottled waters from the Big companies (p-value = 0.0004 < 0.05), among the bottled waters from the Small companies (p-value = 2.12E-06 < 0.05), among the sachet waters from the Small companies (p-value = 0.0191 < 0.05), between the bottled and sachet waters from companies E, F, G and H (p-value = 0.0023 – 0.0171 < 0.0), and between the Big and Small companies bottled waters (p-value = 2.08E-05 < 0.05).

3.4 WQI predicting models for packaged waters

The change in the WQIs of the packaged water samples from the different water packaging companies are described by the linear equations summarized in Table 9. The linear equations have high (0.6125 – 0.8998) to very high (0.9000 – 0.9703) coefficient of determination (R^2), indicating that the linear equations can adequately predict the WQI of the studied packaged water with time. It is interesting to note that packaging type (sachet or bottle) has no noticeable influence on the adequacy (R2 value) of the WQI predicting model. It is believed that the best WQI prediction will be obtained with A_b packaged water while the least WQI prediction will be obtained with J_b packaged water.

Table 9: WQI predicting models for the studied packaged waters

Water sample	Model	R^2
A_b	y = 0.5005x + 29.416	0.9703
B_b	y = 0.352x + 17.629	0.9234
C_b	y = 0.165x + 12.28	0.7627
D_b	y = 0.4655x + 25.731	0.9019
E_b	y = 0.526x + 38.777	0.8958
E_s	y = 0.272x + 42.359	0.804
F_b	y = 0.426x + 31.947	0.9633
F_s	y = 0.0645x + 35.444	0.8998
G_b	y = 0.361x + 22.227	0.7688
G_s	y = 0.6345x + 18.144	0.9382
H_b	y = 0.4x + 36.9	0.7904
H_s	y = 0.198x + 40.736	0.9
I_b	y = 0.195x + 17.535	0.8727
J_b	y = 0.4945x + 30.379	0.9678
K_b	y = 0.225x + 28.595	0.6125

x = time

4. Conclusions

Water samples from eleven water packaging companies (A – K) in Port Harcourt metropolis have been analysed for drinking purposes. The results obtained showed that the physical, chemical and microbiological characteristics of all the water brands met the WHO and SON standards, except for pH, on the day of production for all companies and at six weeks for only two big companies (A and B) and four small companies (E, F, H and K). The results of water quality index (1.24 – 38.88) indicate that all brands were fit for consumption with sample C having the best quality (1.24) while E had the least quality (38.88). A significant difference was observed between the water quality of: bottled waters from the big companies, bottled waters from the small companies, sachet waters from the small companies, bottled and sachet waters from E – H companies, and bottled waters from big and small companies. In all, the tested packaged water brands were found to be safe for drinking within the first six weeks of production.

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