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DETERMINATION OF QUALITY INDEX OF PACKAGED WATER OBTAINED FROM TWO LOCATIONS OF UMUAHIA AND ABA

[1]Amaghionyeodiwe C. A. and [1]Obi A. I.

[1]Department of Mechanical Engineering, Michael Okpara University of Agriculture, Umudike, Umuahia, Abia State, Nigeria
(Email: amaghicyril@gmail.com)

ABSTRACT

The quality of packaged water in Umuahia and Aba was studied using the water quality index (WQI) to determine their purity level. In particular, ten (10) parameters related to quality, viz pH, Turbidity, Electrical Conductivity, Total Dissolved Solids, Total Suspended Solid, Total alkalinity, Iron, Zinc, Chlorine, and Calcium were measured using appropriate measuring instruments. The WQI is computed from these parameters using the weighted arithmetic mean. The results show that the water quality index (WQI) values for Umuahia range from 8.06 to 303.7, implying that it covers the range between excellent water and that unsuitable for drinking. The qualities for Aba range from 33.85 to 91.28 signifying perfect water to good water status. The result also shows that 53% of water samples from Umuahia and 47% from Aba fall in the excellent categories, while 33% and 53% fall in the good water category. In addition, water samples from Aba are safe for consumption, while 7% of the samples from Umuahia are of poor quality and unfit for consumption due to their high electrical conductivity value. This investigation's outcome would assist manufacturers and policy managers in the measures needed to adjust the quality of packaged water for particular applications.

Keywords: *Water Quality Index, Physico-chemical characteristic, packaged water, Umuahia, Aba*

1.0 INTRODUCTION

Drinking (potable) water is the water delivered to the consumer that can be safely used for drinking, food preparation, personal hygiene, and washing (Bos *et al.,* 2016). The water must meet the required chemical, biological, and physical quality standards at the supply point to the users (de Zuane, 1997). Potable water quality is a major ecological determinant of health (WHO, 2010). Investigators have demonstrated that (80%) of sicknesses in developing nations are due to the absence of good quality water (Cheesbrough, 2006), which plays an important role in life sustenance and is a vital mainstay of well-being determinant. Polluted water is a worldwide public health threat setting individuals in danger of a large group of diarrhea and different ailments (Okonko *et al.,* 2009). Megersa (2018) maintains that everybody needs access to safe water in sufficient amounts that do not compromise health or dignity.

A few indices that measure water quality in a comprehensive and expressible way have been developed. Remarkable is the WQI first evolved by Horton in the 1970s (Etim *et al.,* 2013). It is a mathematical means of calculating a single value from multiple test results (Miller *et al.,* 1986). The utilization of WQI improves the aftereffects of an examination identified with a water body cumulating into one worth or idea progression of characteristics investigated. It uncovers whether water bodies' general nature represents an expected danger to different employments of water, especially drinking water supplies. The goal is to transform complex water quality data into justifiable and usable data by the general population. The WQI results are valuable, communicate data concerning water quality as a rule, and give an intelligent thought of the developmental propensity of water quality (Etim *et al.,* 2013).

Researchers have studied the evaluation of water quality using water quality records. For instance, Amadi *et al.* (2010) investigated the use of the Water Quality Index (WQI) in assessing the nature of the Otamiri and Oramiriukwa Rivers for public use, comparing the outcome with Nigerian Standard for Drinking Water Quality (NSDWQ) recommended limit. Results show that the rivers were polluted and that the water is unsafe for domestic use and needs treatment. Olayiwola and Olubunmi (2016) determined the quality of the groundwater and surface water bodies near the central dumpsite location used for disposing of municipal solid waste produced by residents of Ado Ekiti, Nigeria, using the water quality index (WQI) strategy to characterize the water. Results showed that the nature of the groundwater and surface water is poorly inferable from the high substance of lead contained. Ahaneku and Animashaun (2013) determined the water quality index of river Asa by applying the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI). The results of the WQI showed that three of the four stations researched can be positioned as poor and the fourth marginal. Yisa and Jimoh (2010) assessed the nature of River Landzu for public use by applying Water Quality Index (WQI) method, and the outcome contrasted with the World Health Organization (WHO) and Nigerian Industrial Standard (NIS) acceptable recommended limit. It was found that the river was polluted and the water unsafe for domestic use. Etim *et al.* (2013) examined the quality of the stream, borehole, and pipe-borne water in Nigeria's Niger Delta region utilizing the WQI strategy. The

outcomes demonstrate that the pipe borne and borehole water investigated are fit for use. The stream water was undependable for human utilization.

Knowledge of the assessment of packaged water quality in Umuahia and Aba applying the Water Quality Index (WQI) is limited in the literature. This study examines the suitability of packaged water produced in these cities using the Water Quality Index (WQI). The objective of this investigation is to analyze the Physico-chemical characteristics of packaged water such as pH, Turbidity, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Suspended Solid (TSS), Total alkalinity, Iron (Fe), Zinc (Zn), Chlorine (Cl), and Calcium (Ca) contents as recommended by World Health Organization (WHO) and National Standard for Drinking Water Quality (NSDWQ). The outcome of this investigation will be helpful in the management of potable water and aid in policy implementation.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was conducted using packaged water samples in Umuahia and Aba. Umuahia is the capital city of Abia State in southeastern Nigeria on latitude 5.52° N and longitude 7.49° E with a population of 359,230 according to the 2006 Nigerian census (Okoronkwo *et al.,* 2020). It is located along the railroad between Port Harcourt to its south and Enugu to its north. Umuahia is indigenously Igbo and renowned for being a railway and agricultural market center, attracting traders and farmers from neighboring towns to sell their produce, such as yams, cassava, corn (maize), taro, citrus fruits, palm oil, and kernels. Some industries help drive their economies, such as a brewery and a palm oil-processing plant. Umuahia has a tropical climate with significant rainfall and a short dry season with a mean annual temperature of 26.0 °C. Aba (latitude 5.067° N and longitude 7.22° E) is the business hub of Abia State. It is well known for its crafted works. Fig.1 is the map of Abia showing Aba and Umuahia.

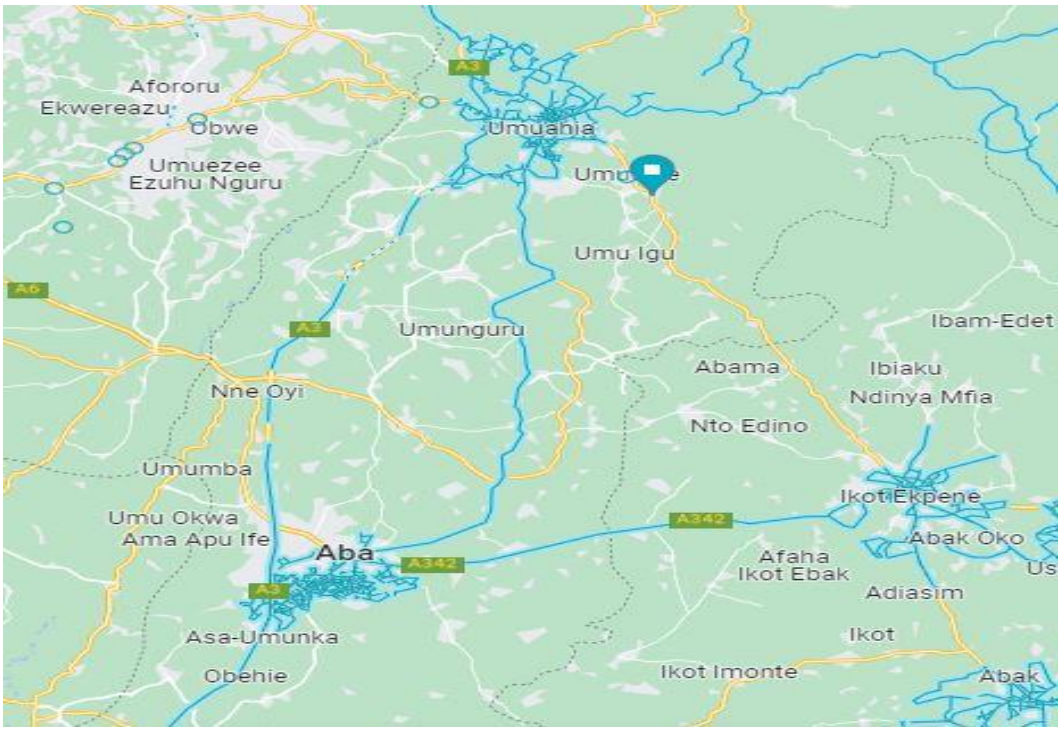

Figure 1: Location of Aba and Umuahia of Abia State in Nigeria (Retrieved from https://maps.google.com)

2.2 Sample collection and analytical procedure

Fifteen brands of 60cl packaged water were used in this investigation and bought from Aba and Umuahia urban communities of Abia State. The samples were labeled ASW1-15 and USW1-15 for Aba and Umuahia samples, respectively. The pH was measured in the laboratory with standardized digital pH meter. Turbidity was measured instrumentally in the laboratory using portable turbidimeter model 2100A. Conductivity meter was used to measure the electrical conductivity of the water samples. Total dissolved solids were measured using a calibrated TDS meter. Iron and Zinc were determined from the sample by the use of Atomic Absorption Spectrophotometer. Calcium and chlorides were determined by titration with ethylenediaminetetracetic acid (EDTA) and Silver Nitrate respectively. Total alkalinity and Total suspended solids were determined using standard methods recommended by the American Public Health Association (APHA 1995) in the Agricultural Engineering and Bioresources

Laboratory of Michael Okpara University of Agriculture, Umudike. The test results are shown in Tables 7 and 8.

2.3 Data analysis

Descriptive statistical analysis was conducted using the statistical package for social science (SPSS) version 23 to determine the association and variation across the physicochemical parameters. One-way analysis of variance (ANOVA) was used to show significant variation at p<0.05 of each Physico-chemical parameter of the water samples in the two cities under investigation.

2.4 Model Selection

This study calculates the water quality index (WQI) using the weighted Arithmetic index method (Brown, 1972). The standards of drinking water quality recommended by the World Health Organization (WHO, 2013), Indian Council for Medical Research (ICMR) (Yogendra and Puttaiah, 2008), and National Drinking Water Quality Standard (NDWQS) (Rahmanian *et al.,* 2015) were used for the calculation of WQI. Each parameter analyzed was assigned unit weight (Wi) and determined using the equation described by Ayobami and Timi (2019):

$$W_i = {}^{k}/_{S_i} \quad (1)$$

$where,$

$W_i = unit\ weight\ of\ i^{th}\ water\ sample\ parameter$

$S_i =$
$standard\ permissible\ value\ of\ i^{th}\ water\ sample\ parameter$

$k = constant\ of\ proportionality\ and\ is\ given\ as$ $(Jai\ et\ al., 2014)$:

$$k = \left[\frac{1}{\left(\sum_{i=1}^{n}\frac{1}{S_i}\right)}\right] \quad (2)$$

$where\ i = 1,2,3,\ldots,n$

The quality rating of i^{th} parameter (Q_i) was calculated as in Olayiwola and Olubunmi (2016):

$$Q_i = 100\left(\frac{V_i - V_{id}}{S_i - V_{id}}\right) \quad (3)$$

$where,$

$V_i =$
$estimated\ value\ of\ i^{th}\ water\ quality\ parameter$

$V_{id} = ideal\ value\ of\ i^{th}\ parameter.$

In this study, V_{id} for $pH = 7$ and zero for all other parameters
$(Jai\ et\ al., 2014;$ Olayiwola and Olubunmi, 2016$)$

Drinking Water standards recommending agencies and unit weight of the physicochemical parameters are shown in Table 1.

Table 1: Drinking water standards recommending agencies and unit weight

S/N	Parameter	Standard Value	Recommended Agency	Unit weight	K
1	pH	8.5	WHO	0.030315	0.257682
2	Turbidity(NTU)	5.0	WHO/NDWQS	0.051536	0.257682
3	EC(ms/cm)	900.0	WHO	0.000286	0.257682
4	TDS(mg/l)	1000.0	WHO/NDWQS	0.000515	0.257682
5	TSS(mg/l)	25.0	NDWQS	0.000258	0.257682
6	Alkalinity (mg/l)	120.0	ICMR	0.002147	0.257682
7	Fe(mg/l)	0.3	WHO	0.858939	0.257682
8	Zn(mg/l)	3.0	NDWQS	0.051536	0.257682
9	Cl(mg/l)	250.0	WHO	0.001031	0.257682
10	Ca (mg/l)	75.0	WHO	0.003436	0.257682

Subsequently, the water quality index (WQI) was computed in accordance with Olayiwola and Olubunmi (2016) as:

$$WQI = \frac{\sum_{i=1}^{n} Q_i W_i}{\sum_{i=1}^{n} W_i} \quad (4)$$

The classification of water quality status based on Water Quality index is shown in Table 2.

Table 2: Water quality classification based on WQI value

Class	WQI Value	Water quality status
I	<50	Excellent
II	50-100	Good water
III	100-200	Poor water
IV	200-300	Very poor water
V	>300	Unsuitable for drinking

Source: $Jai\ et\ al., 2014$

3.0 RESULTS AND DISCUSSION

3.1 Summary of data statistics

The descriptive statistics of the analyzed physicochemical parameters are presented in Tables 3 and 4. The pH values mirror a normal distribution for Umuahia and Aba since their skewness values are approximately zero, which is 0.021 and 0.297, respectively. Calcium (Umuahia) and total alkalinity (Aba) are negatively skewed. This implies that their distributions exhibit a long-left tail indicating lower values below the sample average. Other parameters showed higher values above the sample average (positively skewed). Also, the distribution curve for the total suspended solids (Umuahia and Aba) and Fe (Umuahia) are leptokurtic (peaked curve) because their kurtosis numeric values are greater than three (3), as shown in Tables 3 and 4. Other parameters suggest a flattened and broader distribution curve (platykurtic).

Table 3: **Descriptive statistics of Physico-chemical parameters of packaged water samples from Umuahia**

	pH	Turbidity (NTU)	EC (ms/cm)	TDS (mg/l)	TSS (mg/l)	Alkalinity (mg/l)	Fe (mg/l)	Zn (mg/l)	Cl (mg/l)	Ca (mg/l)
N	15	15	15	15	15	15	15	15	15	15
Mean	6.087	3.593	239.933	27.953	2.2387	69.6840	.2407	3.100	128.600	70.000
Std. Error of Mean	.1348	.1958	31.1846	4.3248	.55069	15.51126	.06502	.1612	2.8632	2.4881
Median	5.900	3.600	222.000	18.400	1.4200	62.2400	.1600	3.200	130.000	70.000
Mode	5.8	3.4[a]	118.0	10.8[a]	1.42	205.00	.11	3.2	132.0	72.0
Std. Deviation	.5222	.7583	120.7775	16.7499	2.13279	60.07487	.25181	.6245	11.0892	9.6362
Variance	.273	.575	14587.210	280.558	4.549	3608.989	.063	.390	122.971	92.857
Skewness	.021	.342	.824	.796	2.509	1.545	2.710	.457	.523	-.117
Std. Error of Skewness	.580	.580	.580	.580	.580	.580	.580	.580	.580	.580
Kurtosis	-1.217	.390	-.292	-.819	6.251	2.387	7.743	-.556	-.703	-.541
Std. Error of Kurtosis	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121
Range	1.6	3.0	374.0	51.6	8.20	203.60	.96	2.0	35.0	32.0
Minimum	5.2	2.2	118.0	10.8	.50	1.40	.08	2.2	115.0	54.0
Maximum	6.8	5.2	492.0	62.4	8.70	205.00	1.04	4.2	150.0	86.0
Sum	91.3	53.9	3599.0	419.3	33.58	1045.26	3.61	46.5	1929.0	1050.0

a. Multiple modes exist. The smallest value is shown

Table 4: Descriptive statistics of Physico-chemical parameters of packaged water samples from Aba

	pH	Turbidity (NTU)	EC (ms/cm)	TDS (mg/l)	TSS (mg/l)	Alkalinity (mg/l)	Fe (mg/l)	Zn (mg/l)	Cl (mg/l)	Ca (mg/l)
N	15	15	15	15	15	15	15	15	15	15
Mean	6.387	3.960	250.773	32.127	3.2267	52.0080	.1593	3.613	132.467	64.000
Std. Error of Mean	.1298	.1882	30.0834	5.0141	.83913	5.07351	.01412	.2490	7.0912	2.2275
Median	6.400	3.800	227.000	22.800	1.8400	60.4000	.1600	3.400	126.000	62.000
Mode	5.8[a]	3.8	88.6[a]	14.2	1.27[a]	1.46[a]	.12	3.4	107.0[a]	58.0[a]
Std. Deviation	.5027	.7288	116.5124	19.4195	3.24993	19.64961	.05470	.9643	27.4639	8.6272
Variance	.253	.531	13575.142	377.118	10.562	386.107	.003	.930	754.267	74.429
Skewness	.297	.771	.616	.680	2.479	-1.589	1.162	.283	1.246	.730
Std. Error of Skewness	.580	.580	.580	.580	.580	.580	.580	.580	.580	.580
Kurtosis	-1.006	-.394	-.288	-1.175	6.419	2.259	1.739	.638	.298	-.047
Std. Error of Kurtosis	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121
Range	1.6	2.3	395.4	52.4	11.93	70.94	.21	3.9	82.0	30.0
Minimum	5.7	3.1	88.6	12.4	1.27	1.46	.09	1.8	104.0	52.0
Maximum	7.3	5.4	484.0	64.8	13.20	72.40	.30	5.7	186.0	82.0
Sum	95.8	59.4	3761.6	481.9	48.40	780.12	2.39	54.2	1987.0	960.0

a. Multiple modes exist. The smallest value is shown

3.2 Analysis of the Physico-chemical characteristics

The pH values range from 5.20 to 6.80 for water samples from Umuahia and 5.70 to 7.30 for those of Aba, with mean values of 6.09 and 6.39, respectively. Water with a pH value less than 7.0 indicates acidity, which communicates the extent of pollution, while values higher than 7.0 indicate alkalinity. Alkaline water shows disinfection in water. The normal drinking water pH range in the World Health Organization (WHO) and the National Standard for Drinking Water Quality (NSDWQ) guidelines is between 6.5 and 8.5 (Table 5). Gas flaring at the neighboring River State may have resulted in acid rain formation coupled with precipitation experience within these localities.

Table 5: The safe limits of WHO and NDWQS for determining drinking water quality

Parameter	WHO limits	NDWQS limits
pH	6.5 – 8.5	6.5 – 9
Turbidity (NTU)	5 – 25	5
Electrical Conductivity (µs/cm)	250	1000
Total Dissolved Solid (mg/l)	600	500
Total Suspended Solid (mg/l)	-	25
Total Alkalinity (mg/l)	80 – 120	-
Fe (mg/l)	0.3	0.3
Zn (mg/l)	5	3
Cl (mg/l)	250	250
Ca (mg/l)	100	60

Source: WHO (2013), NSDWQ (2007).

Water samples USW2, USW3, USW4, USW5, USW9, USW10, USW11, USW12, USW13, USW14, ASW3, ASW4, ASW5, ASW6, ASW8, ASW9, ASW11, ASW13, and ASW14 are acidic with pH value less than 6.50. The mean turbidity values obtained are 3.59NTU and 3.96NTU for Umuahia and Aba, respectively. These agree with the maximum permissible limit of 5.00NTU by the Nigerian Standard for Drinking Water Quality (NSDWQ, 2007) and the World Health Organization

(WHO, 2013). This could be due to the optimal treatment with substances such as alum that cause coagulation of the suspended materials. The conductivity ranges from 118.0 µscm-1 and 492.0 µscm-1 for samples from Umuahia and 88.6µscm-1 and 484.0µscm-1 for those of Aba with mean values of 239.93 µscm-1 and 250.77 µscm-1 for Umuahia and Aba respectively. These values are below the permissible limit of 1000µscm-1 by NSDWQ (2007).

The conductivity results from the solution of irons (Fe) in water (Amadi *et al.,* 2010). The total dissolved solid concentration range for Umuahia samples is 10.8mg/l and 51.6mg/l, with a mean value of 27.95mg/l. At the same time, Aba is 12.4mg/l and 64.8m/l, with a mean value of 32.13mg/l. The mean values conform to the maximum permissible limit of 500 mg/l (NSDWQ, 2007). The results showed that drinking water samples might not cause laxatives or constipation to consumers (Amadi *et al.,* 2010). The mean total suspended solids for water samples from Umuahia and Aba is 2.24 mg/l and 3.23 mg/l, respectively. The total suspended solids of all the drinking water samples from the two locations are below the maximum standard limit of 25 mg/l. The samples' little total suspended solids content indicates that the water samples are well-filtered. This implies that the manufacturers have a well-filtered system.

The maximum recommended total alkalinity limit set by the National Administration for Food, Drugs, and Control (NAFDAC) is 100 mg/l. The total alkalinity value for all the water samples is below the maximum standard limits except for USW9 and USW13, with total alkalinity of 203mg/l.

The average value obtained for iron from the analysis is 0.24mg/l and 0.014mg/l for Umuahia and Aba, respectively. These are lower than the maximum permissible limit of 0.30mg/l (NSDWQ, 2007). Also, zinc concentration ranged from 2.2mg/l and 4.2mg/l for samples from Umuahia and 1.8mg/l and 5.7mg/l for samples from Aba. The mean values are 3.10mg/l and 3.63mg/l, respectively. These values are slightly above the permissible limit of 3.0 mg/l (NSDWQ, 2007). This implies that, on average, water samples from these locations can pose a hazardous risk to human health. The new values of chlorine content are 128.6mg/l and 132.5mg/l for Umuahia and Aba, respectively. These values are below the NSDWQ permissible limit of 250mg/l. The result shows that water samples from the locations are fit for drinking. Amadi *et al.* (2010) affirm that a high chlorine concentration makes the water unpalatable and unfit for drinking and livestock watering. Calcium ions' presence contributes to water's hardness (Amadi *et al.,* 2010). The calcium content ranges from 54mg/l and 86mg/l, with a mean value of 70mg/l for Umuahia water samples. In contrast, those of Aba range from 52 mg/l and 82 mg/l with an average value of 54 mg/l. These qualities are beneath the suggested reasonable restriction of 75mg/l (NSDWQ, 2007).

The analysis of variance (Table 6) shows no statistical difference in the physicochemical characteristics of the water samples from the two locations. pH($F(1,28)=2.57$, MSE = 0.675, p = 0.12), turbidity($F(1,28)=1.823$, MSE = 1.008, p = 0.188), EC($F(1,28)=0.063$, MSE = 881.292, p = 0.804), TDS($F(1,28)=0.397$, MSE = 130.625, p = 0.534), TSS($F(1,28)=0.969$, MSE = 7.321, p = 0.333), alkalinity($F(1,28)=1.173$, MSE = 2343.307, p = 0.288), Fe($F(1,28) =1.494$, MSE = 0.050, p = 0.232), Zn($F(1,28)=2.995$, MSE = 1.976, p = 0.095), Cl($F(1,28)=0.256$, MSE = 112.133, p = 0.617), Ca($F(1,28)=3.228$, MSE = 270.0, p = 0.083).

Table 6: One way analysis of variance comparing the Physico-chemical characteristics of Umuahia and Aba packaged water

Physicochemical Properties		Sum of Squares	df	Mean Square	F	Sig.
pH	Between Groups	.675	1	.675	2.570	.120
	Within Groups	7.355	28	.263		
	Total	8.030	29			
Turbidity(NTU)	Between Groups	1.008	1	1.008	1.823	.188
	Within Groups	15.485	28	.553		
	Total	16.494	29			
EC(ms/cm)	Between Groups	881.292	1	881.292	.063	.804
	Within Groups	394272.923	28	14081.176		
	Total	395154.215	29			
TDS(mg/l)	Between Groups	130.625	1	130.625	.397	.534
	Within Groups	9207.467	28	328.838		
	Total	9338.092	29			
TSS(mg/l)	Between Groups	7.321	1	7.321	.969	.333
	Within Groups	211.552	28	7.555		
	Total	218.873	29			
Alkalinity (mg/l)	Between Groups	2343.307	1	2343.307	1.173	.288

	Within Groups	55931.353	28	1997.548		
	Total	58274.660	29			
Fe	Between Groups	.050	1	.050	1.494	.232
	Within Groups	.930	28	.033		
	Total	.979	29			
Zn	Between Groups	1.976	1	1.976	2.995	.095
	Within Groups	18.477	28	.660		
	Total	20.454	29			
Cl	Between Groups	112.133	1	112.133	.256	.617
	Within Groups	12281.333	28	438.619		
	Total	12393.467	29			
Ca (mg/l)	Between Groups	270.000	1	270.000	3.228	.083
	Within Groups	2342.000	28	83.643		
	Total	2612.000	29			

The computed WQI of the water samples accessed is presented in Tables 7 and 8 for Umuahia and Aba, respectively. The highest WQI recorded for Umuahia is 303.65 for USW12, depicting that the water sample is unsuitable for drinking. This is closely followed by USW13 (168.36), signifying poor water. Water samples USW1 (35.39), USW3 (39.38), USW4 (30.77), USW5 (48.82), USW8 (8.06), USW10 (32.04) and USW14 (39.66) are safe for drinking (Table 5). Similarly, the highest value for Aba samples is 91.28 (ASW9), followed by 67.27 (ASW14). This depicts good water samples. Water samples ASW1 (44.46), ASW4 (33.85), ASW8 (38.12), ASW10 (38.34), ASW11 (43.04), ASW12 (39.08) and ASW13 (41.48) are safe for consumption (Table 6). These WQI values are summarized in Table 9.

Table 7: Computed Water Quality Index for packaged water samples from Umuahia

Sample	pH	Turbidity (NTU)	EC (ms/cm)	TDS (mg/l)	TSS (mg/l)	Alkalinity (mg/l)	Fe (mg/l)	Zn (mg/l)	Cl (mg/l)	Ca (mg/l)	Qi*Wi	QWI
USW1	6.4	3.6	220	10.8	1.16	1.42	0.1	2.6	119	68	35.393	35.393
USW2	6.2	2.8	118	18.4	1.12	62.42	0.19	3.2	136	72	61.087	61.087
USW3	5.7	4.6	153	16.2	5.6	62.72	0.11	2.6	116	65	39.380	39.380
USW4	5.8	3	126	17.2	1.21	64.64	0.08	4.2	121	60	30.773	30.773
USW5	5.4	4.2	132	32.6	8.7	62.24	0.14	3.8	130	70	48.823	48.823
USW6	6.7	4.2	118	47.6	1.66	6.8	0.22	3	122	86	70.875	70.875
USW7	6.7	5.2	428	12.2	0.5	58.2	0.16	2.8	146	69	54.551	54.551
USW8	6.8	3.8	382	46.2	1.6	68.3	0.31	3.4	115	65	8.060	8.060
USW9	6.4	2.2	242	46.8	1.42	205	0.2	3.2	132	72	63.592	63.592
USW10	5.2	3.4	234	13.4	2.4	58.4	0.09	2.2	132	72	32.038	32.038
USW11	5.8	3.6	324	17.6	1.8	68.2	0.12	2.4	116	54	40.971	40.971
USW12	5.8	2.9	284	62.4	2.4	58.7	1.04	2.4	140	54	303.654	303.654
USW13	5.7	3.8	222	42.8	1.42	205	0.56	3.2	150	81	168.362	168.362
USW14	5.9	3.2	124	18.6	1.17	61.82	0.11	4.2	122	82	39.664	39.664
USW15	6.8	3.4	492	16.5	1.42	1.4	0.18	3.3	132	80	58.479	58.479

Table 8: Computed Water Quality Index for packaged water samples from Aba

Sample	pH	Turbidity (NTU)	EC (ms/cm)	TDS (mg/l)	TSS (mg/l)	Alkalinity (mg/l)	Fe (mg/l)	Zn (mg/l)	Cl (mg/l)	Ca (mg/l)	Qi*Wi	QWI
ASW1	7.3	3.1	484	14.2	1.44	1.46	0.12	5.7	126	78	44.463	44.463
ASW2	6.8	3.2	88.6	18	1.84	18.4	0.19	4.2	186	65	62.035	62.035
ASW3	6.4	3.8	104	22.8	4.6	67.2	0.16	2.8	112	56	51.829	51.829
ASW4	5.8	5.4	261	27.6	13.2	64.8	0.09	4.3	132	72	33.853	33.853
ASW5	6.2	4.2	128	42	7.6	42	0.21	3.4	180	58	66.766	66.766
ASW6	6.4	3.4	227	48.2	2	60.6	0.18	4.6	107	64	59.028	59.028
ASW7	6.9	3.8	226	42.6	1.85	58.7	0.18	2.4	132	62	58.180	58.180

ASW8	5.8	3.8	182	18.4	3.8	64.02	0.12	1.8	122	54	38.124	38.124
ASW9	6.2	3.2	187	12.4	1.27	46.12	0.3	3.2	182	52	91.277	91.277
ASW10	6.6	3.4	230	18.2	1.5	60.4	0.11	3.6	122	60	38.344	38.344
ASW11	5.7	4.4	204	15.4	1.6	48.2	0.13	3.4	104	58	43.036	43.036
ASW12	6.7	4.2	412	64.8	3.2	64.2	0.11	3.2	128	82	39.079	39.079
ASW13	5.9	5.2	416	64.2	1.8	72.4	0.12	3.4	126	62	41.484	41.484
ASW14	6	4.8	324	58.9	1.28	67	0.21	3.6	121	71	67.274	67.274
ASW15	7.1	3.5	288	14.2	1.42	44.62	0.16	4.6	107	66	54.798	54.798

Table 9: Summary of the Quality Water Index results for Umuahia and Aba

UMUAHIA			**ABA**		
Sample	**QWI**	**Remarks**	**Sample**	**QWI**	**Remarks**
USW1	35.393	Excellent	ASW1	44.463	Excellent
USW2	61.087	Good water	ASW2	62.035	Good water
USW3	39.380	Excellent	ASW3	51.829	Good water
USW4	30.773	Excellent	ASW4	33.853	Excellent
USW5	48.823	Excellent	ASW5	66.766	Good water
USW6	70.875	Good water	ASW6	59.028	Good water
USW7	54.551	Good water	ASW7	58.180	Good water
USW8	8.060	Excellent	ASW8	38.124	Excellent
USW9	63.592	Good water	ASW9	91.277	Good water
USW10	32.038	Excellent	ASW10	38.344	Excellent
USW11	40.971	Excellent	ASW11	43.036	Excellent
USW12	303.654	Unsuitable for drinking	ASW12	39.079	Excellent
USW13	168.362	Poor water	ASW13	41.484	Excellent
USW14	39.664	Excellent	ASW14	67.274	Good water
USW15	58.479	Good water	ASW15	54.798	Good water

Eight (8) out of the fifteen (15) samples from Umuahia are safe for drinking, while those of Aba are Seven (7), representing 53% and 47% proportion (Figure 2) of the entire WQI distribution, respectively. Umuahia has one sample as poor and unsuitable for drinking, occupying 7% of the whole WQI (Figure 2), and Aba has none.

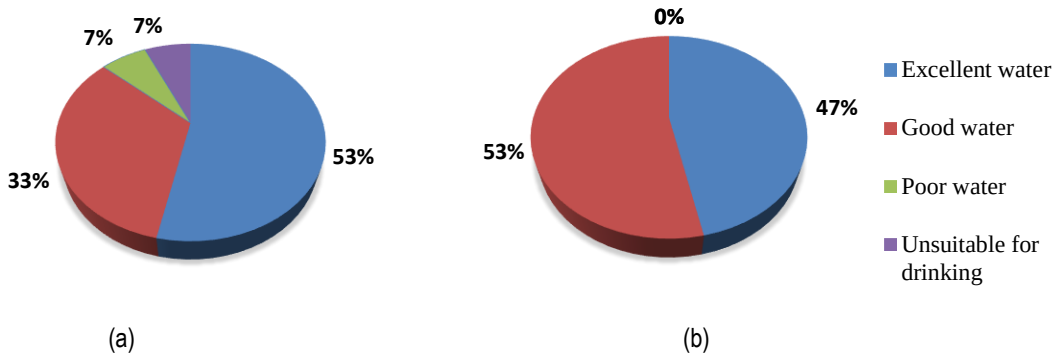

Figure 2: Breakdown of Water quality classification based on WQI value (per cent) for (a) Umuahia and (b) Aba packaged water samples

4.0 CONCLUSION

The water quality index of packaged water has been investigated to assess its suitability for drinking purpose in Umuahia and Aba, Abia State. Fifteen (15) samples each were collected from the selected locations, and a comprehensive Physico-chemical analysis was carried out. Physico-chemical parameters were used to calculate the WQI values for Umuahia and Aba. The values for Umuahia ranges from 8.06 to 303.7, and for Aba, 33.85 to 91.28. The outcome of this investigation serves as part of qualitative monitoring of the quality of packaged water produced in the study area.

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