

Assessment of physicochemical status of some bottled and sachet water samples sold in Aba and Umuahia Cities of Abia State, Nigeria

Abstract

As packaged drinking water in the form of bottled and sachet water are very common in Nigeria, this study presents the results of the assessment of some bottled and sachet water sold in Aba and Umuahia cities of Abia state to ascertain their level of compliance with World Health Organization (WHO) and Standard Organization of Nigeria (SON) specifications for drinking water. Three different brands of bottled water and 3 different brands of sachet water were sampled from shops in Aba and Umuahia respectively. The samples were physically examined and their physicochemical parameters analyzed using standard analytical procedure. The results from physical examination shows that all the water brands had product name, manufacturer's name and NAFDAC number. The parameters investigated showed the following results: For Aba, $pH_{\text{bottledwater}} (6.91 \pm 0.07 - 7.39 \pm 0.10)$; $pH_{\text{sachetwater}} (6.00 \pm 0.02 - 6.41 \pm 0.04)$; $TDS_{\text{bottledwater}} (86.67 \pm 5.77 \text{ mg/L} - 106.67 \pm 5.72 \text{ mg/L})$; $TDS_{\text{sachetwater}} (66.67 \pm 5.77 \text{ mg/L} - 86.67 \pm 5.77 \text{ mg/L})$; $TSS_{\text{bottledwater}} (31.00 \pm 1.73 \text{ mg/L} - 79.33 \pm 1.16 \text{ mg/L})$; $TSS_{\text{sachetwater}} (30.67 \pm 1.16 \text{ mg/L} - 89.00 \pm 1.00 \text{ mg/L})$; $EC_{\text{bottledwater}} (59.30 \pm 0.61 \text{ } \mu\text{S/cm} - 177.33 \pm 0.58 \text{ } \mu\text{S/cm})$; $EC_{\text{sachetwater}} (28.33 \pm 0.58 \text{ } \mu\text{S/cm} - 107.00 \pm 6.08 \text{ } \mu\text{S/cm})$; Temperature $_{\text{bottledwater}} (29.35 \pm 0.08^\circ\text{C} - 30.12 \pm 0.01^\circ\text{C})$; Temperature $_{\text{sachetwater}} (29.80 \pm 0.10^\circ\text{C} - 29.90 \pm 0.17^\circ\text{C})$. For Umuahia, $pH_{\text{bottledwater}} (6.69 \pm 0.01 - 7.48 \pm 0.02)$; $pH_{\text{sachetwater}} (4.42 \pm 0.51 - 7.15 \pm 0.06)$; $TDS_{\text{bottledwater}} (74.33 \pm 4.04 \text{ mg/L} - 89.33 \pm 1.16 \text{ mg/L})$; $TDS_{\text{sachetwater}} (47.67 \pm 2.52 \text{ mg/L} - 80.67 \pm 1.16 \text{ mg/L})$; $TSS_{\text{bottledwater}} (27.67 \pm 2.52 \text{ mg/L} - 59.33 \pm 1.16 \text{ mg/L})$; $TSS_{\text{sachetwater}} (49.33 \pm 1.16 \text{ mg/L} - 68.67 \pm 8.08 \text{ mg/L})$; $EC_{\text{bottledwater}} (5.33 \pm 0.58 \text{ } \mu\text{S/cm} - 31.33 \pm 1.53 \text{ } \mu\text{S/cm})$; $EC_{\text{sachetwater}} (6.33 \pm 1.16 \text{ } \mu\text{S/cm} - 36.67 \pm 0.58 \text{ } \mu\text{S/cm})$; Temperature $_{\text{bottledwater}} (29.13 \pm 0.39^\circ\text{C} - 29.16 \pm 0.36^\circ\text{C})$; Temperature $_{\text{sachetwater}} (29.27 \pm 0.55^\circ\text{C} - 29.83 \pm 0.06^\circ\text{C})$. All the above mentioned parameters are within the acceptable limits set by WHO and SON, except the pH of sachet water from both Aba and Umuahia. Also, results obtained show that DO, chloride, sulphate, fluoride and nitrate values for all the water samples are within the acceptable limit by WHO and SON.

Keywords: physicochemical parameters, WHO, SON, bottled water, Aba, Umuahia

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Abbreviations: pH, hydrogen ion concentration; TDS, total dissolved solids; TSS, total suspended solids; EC, electrical conductivity; WHO, World Health Organization; SON, standard organization of Nigeria; NIS, Nigerian industrial standard; NAFDAC, National agency for food and drug administration and control

Introduction

Water is of fundamental importance for life on earth. It is an essential constituent and ingredient of animal and plant lives, covering about 70% of the planet's surface. It occurs as flowing water (in oceans, rivers, springs and streams) and standing water (lakes), with different degrees of purity. Despite its relative abundance, quality drinking water is not readily available to man.¹ Hence, inadequate access to safe water and sanitation services can cause sicknesses and consequential death in children. Also, the World Health Organization (WHO) states that polluted water can lead to spread of water-borne illnesses such as cholera, typhoid and dysentery.²

The rising concern about public health has led most people to choose packaged drinking water (bottled and sachet water) over tap or bore-hole water as they assume that such water is safe for consumption.

Sachet water can be referred to as ready to drink, packed and machine-sealed water,³ and found as a major source of water at food

canteens and sold by many food vendors in the country.⁴ It is normally referred to as 'pure water' by many of the locals in Nigeria and other neighboring African countries such as Ghana, Niger, Togo, etc.⁴

However, as Nigeria ranks third on the global list of countries with inadequate water supply and sanitation coverage,⁵ this has given chance to private individuals to invest in the production of packaged drinking water.⁶ The situation has automatically led to the production of many brands of bottled and sachet (pure) water in every nook and cranny of the country, and Abia state is no exception. Generally, the high income group go for bottled water whose manufacturing practices and hygiene standards were high and expensive,⁷⁻⁹ while the low income group resorted to dependence on sachet ('pure') water; as it is financially affordable to the common populace.¹⁰ However, this category of packaged water (sachet water), has some positive socio-economic impact as it reduces societal crimes and improves standard of living through youth empowerment.¹¹

Aba is a densely populated commercial city in Abia state, South Eastern Nigeria, which is located within the coordinates $5^\circ 07' \text{ N}$ and $7^\circ 22' \text{ E}$. Its inhabitants are mainly traders, artisans and local farmers. Whereas, Umuahia is the capital city of Abia state and located within the coordinates $5^\circ 31' \text{ N}$ and $7^\circ 28' \text{ E}$. The main occupation of inhabitants here include civil service, education, trading and farming.

In Aba and Umuahia cities, several brands of bottled and sachet water are available on sale but most studies have only investigated the quality of drinking water sourced from rivers and boreholes;¹²⁻¹⁹ although, a study has been conducted on quality of bottled water sold in Umuahia metropolis.²⁰

The present study therefore seeks to investigate some of the physico-chemical parameters of bottled and sachet water sold in Aba and Umuahia cities of Abia state and their level of compliance with World Health Organization standard (WHO) and Standard Organization of Nigeria (SON)/ National Agency for Food and Drug Administration and Control (NAFDAC) for safe drinking water.

Water is said to be potable when its physical, chemical and microbiological qualities conform to specified standards [1]. Physicochemical parameters are parameters that ascertain the quality of water. These comprise of physical parameters like color, odor, taste, turbidity, temperature, etc. Chemical parameters include pH, conductivity, dissolved oxygen (DO), biochemical oxygen demand (BOD), alkalinity, nitrite, nitrate, metal content, etc.; while biological parameters include pathogenic bacteria, pathogenic viruses and parasites.²¹

Materials and methods

Samples

Samples A, B and C = Bottled water from Aba.

Samples D, E and F = Sachet water from Aba.

Samples G, H and I = Bottled water from Umuahia.

Samples J, K and L = Sachet water from Umuahia

Study area

The study was carried out in Aba and Umuahia cities of Abia state. Aba is a densely populated commercial city in Abia state, South Eastern Nigeria, which is located within the coordinates 5° 07' N and 7° 22' E. Its inhabitants are mainly traders, artisans and local farmers. Whereas, Umuahia is the capital city of Abia state and located within the coordinates 5° 31' N and 7° 28' E. The main occupation of inhabitants here include civil service, education, trading and farming.

Sample collection

Three different brands of bottled water and three different brands of sachet water samples were purchased in triplicate from shops at Aba and Umuahia cities respectively, with the brand names labeled A, B, C for Aba bottled water, D, E, F for Aba sachet water samples. Also, G, H, I for Umuahia bottle water, J, K, L for Umuahia sachet water samples. They were physically examined to observe the appearance and the labeling information and taken to the laboratory for the assessment of their physicochemical parameters.

Physicochemical analysis

pH and conductivity: The pH, temperature, electrical conductivity (EC) and total dissolved solids (TDS) of the water samples were determined using a pre-calibrated 4-parameter hand-held digital portable H18339-9 pH/EC/TDS/TEMP meter. The probe was inserted into the water samples and the readings for pH, EC, TDS and temperature were observed. Measurements of each sample were made in triplicate and the mean values recorded.

Total Suspended Solids (TSS)

The total suspended solids (TSS), were determined by gravimetric method. Water sample (100 ml) was filtered through a pre-weighed

Whatman glass fibre filter. The filter was dried in an oven to constant weight at 105 °C and was re-weighed. TSS was determined as:

$$TSS (mg/l) = \frac{W_2 - W_1}{V} \times 1000 \quad (1)$$

W_1 = Initial weight of filter, W_2 = final weight of filter, V = volume of sample

Determination of Dissolved Oxygen (DO)

The dissolved oxygen (DO), was determined by titrimetric method.²²

This method involved the preparation of N/80 of $Na_2S_2O_3 \cdot 5H_2O$ solution in a 250 mL volumetric flask by dissolving 0.775 g of $Na_2S_2O_3 \cdot 5H_2O$ in distilled water with a few drops of 0.1N Na_2CO_3 . The volume was made up to the mark by adding distilled water. 50% $MnSO_4$ Solution was also prepared by weighing 50 g of $MnSO_4 \cdot 5H_2O$, dissolving it in distilled water in a 100 mL volumetric flask and making up to mark. This was followed by the preparation of 20% Alkaline KI solution making the volume in a 100 mL volumetric flask up to mark with distilled water after dissolving 49 g of NaOH, 20 g of KI, and 0.5g of sodium azide in same solvent.

Procedure: The water sample was properly collected in a 250 mL volumetric flask, avoiding any kind of bubbling and trapped it into the bottle. 5 mL of water was withdrawn from the bottle, 2 mL of manganese sulphate (50 % $MnSO_4$) was poured from the bottle wall, and 2 mL of alkaline KI solution (20 % KI) was added deep below the surface. A precipitate appeared. The stopper was then tightened, and the bottle was shaken frequently by inverting it to ensure thorough mixing of the contents. After allowing the precipitate to settle, the bottle was filled with 85 % concentrated H_3PO_4 and shaken vigorously to dissolve all the precipitates. Then, using starch as an indicator, 50 mL of sample was placed in a conical flask and titrated against a sodium thiosulphate ($Na_2S_2O_3$) solution of 0.0125 N strength. The original blue color had faded to a colorless state towards the end. DO is calculated adopting the following formula:

$$DO (mg/L) = \frac{(mL \times N) \text{ of Titrant} \times 8 \times 1000}{V_2 \times \frac{V_2 - V}{V_2}} \quad (2)$$

Where:

V_1 = Volume of Sample bottle after placing the stopper.

V_2 = Volume of part of content titrated.

V = Volume of $MnSO_4$ and KI added.

Determination of nitrate

The determination of nitrate was by spectrophotometry.²³

The complex formed by nitration of salicylic acid under highly acidic conditions absorbs maximally at 410nm in basic (pH>12) solutions. Absorbance of the chromophore is directly proportional to the amount of nitrate-N present, while ammonium, nitrite and chloride ions do not interfere.

Standards

Stock Solution of 0.25g/L NO_3^- -N (=250mg/L or 250µg/mL): In a 1000 Standard Flask containing approximately 1000mL distilled water, dissolve 10mg potassium nitrate.

Blanks

A blank of 0.25 mL H_2O with the normal reagents is normally sufficient.

This blank shall consist of the distilled water 0.25ml, 0.8 mL of conc H₂SO₄ (minus salicylic acid) and 19 mL of 2 N NaOH

Reagents

Salicylic acid-H₂SO₄: 5g of salicylic acid was dissolved in 100 mL of conc H₂SO₄. The salicylic acid-H₂SO₄ reagent should be made fresh every week and stored in a brown bottle. Nitrate standards should be stored at 4°C.

2 N NaOH

40.0 g of NaOH pellets were dissolved with 100 mL of water in 250mL beater and then transferred to a 500 mL volumetric flask and make up to 500.0 mL with deionized water.

Procedure

An aliquot (e.g. 1 mL) of the standard solution was pipetted into a 50-mL Erlenmeyer flask and mixed thoroughly with 0.8 mL of 5% (w/v) salicylic acid in conc. H₂SO₄.

After 20 minutes at room temperature, 19 mL of 2N NaOH were added to raise the pH above 12 and the samples were cooled to room temperature and the absorbance was measured at 410nm with the spectrophotometer.

Determination of sulphate: The status of sulphate was determined turbidimetrically.²⁴ This method is based on the fact that barium chloride (BaCl₂) precipitates sulphate (SO₄²⁻) in its solution to form barium sulphate (BaSO₄) which is insoluble in water and the turbidity measured spectrometrically.

Procedure: 50ml of sample was measured into a beaker which was then digested with 5mL of HNO₃. Again, about 5mL of the filtrate was then pipetted into a test tube and a pinch of BaCl₂ crystal added and allowed to stand for one and half hours. The absorbance was then read off spectrometrically at wavelength of 425 nm.

Determination of chloride by argentometry;²²

Preparation of potassium chromate indicator solution: In a small amount of distilled water, 5g potassium chromate was dissolved and silver nitrate solution was added till the formation of the red precipitate. After allowing the solution to stand for 12 hours, it was filtered and distilled water was used to get the volume up to 100 mL.

Standardization of N/50 AgNO₃ with N/50 NaCl solution: 10 mL of N/50 NaCl solution was pipetted out in a 250 mL conical flask and 1 mL of 2% K₂CrO₄ solution was added to this solution. AgNO₃ was taken in a burette and then titrated against this solution till a faint red color precipitate appeared.

Methodology

To proceed, fill the burette with standard AgNO₃ and titrate by adding 2 mL of 2% K₂CrO₄ to 50mL of water sample until a faint red color precipitate emerged in the volumetric flask. It was noted how often AgNO₃ was required for this endpoint. The chloride was precipitated as silver Chloride, and the titration was completed when the color of the potassium chromate indicator changed from yellow to pinkish yellow. Chloride was calculated adopting the following formula:

$$\text{Chloride (mg/L)} = \frac{(a - b) \times N \times 35.5 \times 1000}{V} \quad (3)$$

Where:

a= volume of titrant (silver nitrate) for sample.

b= volume of titrant (silver nitrate) for blank.

V= volume of the sample in mL.

N= Normality of silver nitrate.

Fluoride determination by Spectrophotometry²⁵

Resorcin blue and aluminum chloride hexahydrate were used. All the chemicals were of analytical reagent grade except where stated otherwise. Solutions were prepared using double distilled water. Resorcin blue ligand solution and the aluminum complex solution were prepared using ethanol from Merck (reagent 96%, 159010).

Standard fluoride stock solution was prepared by dissolving 0.1382 g of sodium fluoride provided by Merck in 250 ml water. The stock solution was further diluted as needed.

The complex solutions for the spectrophotometric measurements were prepared by mixing aluminum 1:1 resorcin blue ratio of 5 × 10⁻³ M of aluminum chloride and 5 × 10⁻³M of resorcin blue in ethanol solution, which was then suitable for the spectrophotometric measurements.

2ml of digested samples were added to 25 ml volumetric flask containing 0.5ml of aluminum chloride and 4.5ml of resorcin blue. The solution was made up to volume by water. The absorbance was measured at the wavelength of 624 nm.

The standard will be treated same as sample and measured at 624nm.

Results

The results of the physical examination of bottled and sachet water from Aba and Umuahia cities are shown in Table 1 and Table 2 below, respectively.

Table 1 Results of physical examination of bottled and sachet water from Aba

Sample	Product name	Manufacturer's address	Manufacturing date	Batch no	Expiry date	NAFDAC no	Mineral composition
A	+	+	-	-	-	+	+
B	+	+	+	-	+	+	-
C	+	+	-	-	-	+	-
D	+	+	-	-	-	+	-
E	+	+	-	-	-	+	-
F	+	+	-	-	-	+	-

+, Indicated; -, Not Indicated; A-C, Bottled water; D-F, Sachet water

Table 2 Results of physical Examination of Bottled and Sachet water from Umuahia

Sample	Product name	Manufacturer's address	Manufacturing date	Batch no	Expiry date	NAFDAC no	Mineral composition
G	+	+	+	-	+	+	-
H	+	+	+	-	+	+	-
I	+	+	+	-	-	+	-
J	+	+	-	-	-	+	-
K	+	+	-	-	-	+	-
L	+	+	-	-	-	+	-

+, Indicated; -, Not Indicated; G – I, Bottled water; J – L, Sachet water

The National Agency for Food, Drug Administration and Control (NAFDAC) requires that all the labeling of food and drugs must be informative and accurate. This information required on labeling include Producers name, Contact information, Batch number, Nutritional information, Expiration date (Best before date), Manufacturing date and NAFDAC registration number.⁶

Table 1 and Table 2 revealed that all the bottled and sachet water investigated had 100% compliance in terms of the product names, manufacturing addresses, and NAFDAC number. These information are however essential as it tells the consumer whether the water sample is still within its shelf life or not. Moreover, all the bottled and sachet water were observed to be without batch number. Batch number is essential for any product especially when there is need to

recall a product from the market by the water production factories as truly observed in this present study is a source of great concern as the packaged water sold to the entire public are liable to cause health risk when consumed. However, all the bottled and sachet water were duly certified to operate as evident in the NAFDAC registration provided.

The physicochemical parameters of the water samples investigated include pH, total dissolved solids (TDS), total suspended solids (TSS), electrical conductivity (EC), temperature, chloride, dissolved oxygen (DO), sulphate, fluoride and nitrate.

Below are Tables 3–5 showing the results of the physicochemical analyses of bottled and sachet water samples from Aba and Umuahia respectively.

Table 3 Results of Mean and Standard Deviation of physicochemical analyses of bottled and sachet water from Aba

Samples	pH	TDS (mg/L)	TSS (mg/L)	EC (µS/cm)	Temperature (°C)
A	6.91±0.07	106.67±5.72	31.00±1.73	66.00±1.00	29.35±0.08
B	7.39±0.10	100.00±10.00	79.33±1.16	177.33±0.58	30.12±0.01
C	6.92±0.06	86.67±5.72	62.33±2.52	59.30±0.61	29.37±0.06
D	6.39±0.07	66.67±5.77	89.00±1.00	107.00±6.08	29.80±0.10
E	6.00±0.02	86.67±5.77	30.67±1.16	28.33±0.58	29.90±0.17
F	6.41±0.04	86.67±5.77	57.67±2.52	73.33±0.58	29.87±0.12
WHO	6.5-8.5	500	<500	1000	25-32
SON	6.5-8.5	500	-	-	-
NIS	6.5-8.5	500	-	1000	Ambient

WHO (2011), SON (2007), NIS (Nigeria Industrial Standard for potable water, 2007).

Table 4 Results of Mean values of chemical analyses of bottled and sachet water from Aba

Samples	Chloride (mg/L)	DO (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Nitrate (mg/L)
A	41	15.3	17.6	0.17	13.64
B	38	15.7	17.2	0.15	14.54
C	41	14.6	15.2	0.16	13.29
D	40	15.1	14.11	0.19	21.61
E	59	15.8	10.15	0.31	20.41
F	6	15.1	3	0.11	21.9
WHO	250	250	100	1.5	50
SON	200	250	100	1.5	50
NIS	250	250	100	1.5	50

WHO (2011), SON (2007), NIS (2007), A –C, Bottled Water, D –F, Sachet water

Table 5 Result of physicochemical analyses of bottled and sachet water from Umuahia

Parameter	G	H	I	J	K	L	WHO	SON	NIS
pH	7.25±0.05	6.69±0.01	7.48±0.02	4.62±0.17	4.42±0.51	7.15±0.06	6.5-8.5	6.5-8.5	6.5-8.5
TDS (mg/L)	74.33±4.04	82.67±4.62	89.33±1.16	59.33±1.16	80.67±1.16	47.67±2.52	500	500	500
TSS (mg/L)	29.33±1.16	27.67±2.52	59.33±1.16	57.00±2.65	68.67±8.08	49.33±1.16	<500	-	-
EC (µS/cm)	31.33±1.53	5.33±0.58	11.33±1.16	32.00±2.00	36.67±0.58	6.33±1.16	1000	-	1000
Temperature (°C)	29.16±0.36	29.13±0.39	29.15±0.43	29.27±0.55	29.50±0.52	29.83±0.06	25-32	-	Ambient
Chloride (mg/L)	118	100	107	41	49	45	250	200	250
DO (mg/L)	13.2	14.4	13.2	13	12.8	13.4	250	250	250
Sulphate (mg/L)	54.8	71.23	63.93	17.33	10.57	11.69	100	100	100
Fluoride (mg/L)	0.27	0.27	0.43	0.1	0.05	0	1.5	1.5	1.5
Nitrate (mg/L)	22.11	22.09	22.62	13.91	14.38	17.47	50	50	50

WHO (2011), SON (2007), NIS (2007); G –I, Bottle water, J –L, Sachet water

pH: Tables 3–5 constitute the physicochemical analyses of the bottled and sachet water samples from Aba and Umuahia respectively. The pH values of bottled water (A-C) and (G-I), from Aba and Umuahia ranged from 6.91± 0.07 -7.39± 0.10; and 6.69±0.01 -7.48±0.02 respectively. The pH level of the bottled water is within the permissible limit of 6.5-8.5 by WHO and SON/NIS. This also agrees with the study by Chioma and Egoka.¹⁹ Also, the pH of sachet water samples (D-F) and (J-L) from Aba and Umuahia ranged from 6.00±0.02 -6.41± 0.04; and 4.42± 0.51 -7.15± 0.06. This revealed that the sachet water samples from Aba fall a little below WHO and SON permissible limit, while the samples from Umuahia ranged from acidic to normal. The variation in pH of the sachet water could be as a result of different water sources, which indicate that some water are more acidic while some are basic. However, Aliyu et al.,²⁶ in their study also noted a similar variation in the pH of water samples.

Total Dissolved Solids (TDS): The TDS of bottled water from Aba and Umuahia ranged from 86.67±5.72 -106.67 ±5.72mg/L, and 74.33±4.04 - 89.33± 1.16mg/L. While the sachet water samples ranged from 66.67±5.77 - 86.67± 5.77mg/L, and 47.67±2.52 -80.67±1.16mg/L respectively. The TDS of all the water samples were within the 500mg/L by WHO and SON. The total dissolved solid is a measure of the level of dissolved solid in water and can affect the taste of drinking water if above the WHO limit of 500mg/L.³

Total Suspended Solids (TSS): The TSS values of bottled water from Aba and Umuahia ranged from 31.00±1.73 - 79.33±1.16mg/L, and 27.67±2.52 -59.33±1.16mg/L respectively. While TSS for sachet water ranged from 30.67±1.16 - 89.00±1.00mg/L for Aba; and 49.33±1.16 -68.67± 8.08mg/L for Umuahia. All the water samples were within the stipulated limit of <500mg/L by WHO.

Electrical Conductivity (EC): The EC values of bottled water from Aba and Umuahia ranged from 59.30±0.61 -177.33±0.58µS/cm, and 5.33±0.58 -31.33±1.53µS/cm respectively. For sachet water, the EC values ranged from 28.33±0.58 - 107.00±6.08µS/cm for Aba and 6.33±1.16 -36.67±0.58µS/cm for Umuahia. All the water samples have EC values within the permissible limit of 1000µS/cm by WHO and NIS. However, a long term drinking of water with EC value less than 40µS/cm constitute a number of health risks such as higher probability of fracture in children, pregnancy disorder (preeclampsia), diuresis, premature or low baby weight at birth and increased tooth decay.²⁷

Temperature: Temperature is a measure of the average thermal energy of a substance.³ The temperature of bottled water from Aba and Umuahia ranged from 29.35±0.08 -30.12±0.01°C, and 29.13±0.39

-29.16±0.36°C respectively. This value of temperature conforms to the study by Chioma and Egoka on bottled water in Umuahia metropolis.¹⁹ Also, the temperature of the sachet water ranged from 29.80±0.10 -29.90±0.17°C and 29.27±0.55 -29.83±0.06°C for Aba and Umuahia respectively. The temperature falls within WHO limit of 25 -32°C, whereas there is no standard set by SON.

Chlorides: The chloride ion concentration of bottled water in Aba and Umuahia ranged from 38.00 -41.00mg/L and 100.00 -118.00mg/L respectively. Also in sachet water, it ranged from 6.00 -59.00mg/L and 41.00 -49.00mg/L for Aba and Umuahia respectively. All these values were within WHO and SON guideline value of maximum permissible concentration of 250mg/L and 200mg/L respectively.

Dissolved Oxygen (DO): The dissolved oxygen (DO) for bottled water in Aba and Umuahia ranged from 14.60 -15.70mg/L; and 13.20 -14.40mg/L respectively; and in sachet water, 15.10 -15.80mg/L and 12.80 -13.40mg/L respectively. This revealed that the DO values for all the water samples were WHO and SON permissible limit of 250mg/L.

Sulphate: The Sulphate ion concentrations in bottled water ranged from 15.20 -17.60mg/L; and 54.80 -71.23mg/L in Aba and Umuahia respectively. Whereas for the sachet water, sulphate ion concentration ranged from 3.0 -14.11mg/L, and 10.59 - 17.33mg/L for Aba and Umuahia respectively. All these values are within the WHO and SON permissible limit of 100mg/L.

Fluoride: The level of fluoride in bottled water ranged from 0.15 -0.17mg/L and 0.27 -0.43mg/L in Aba and Umuahia respectively. While in sachet water, the fluorides ranged from 0.11 -0.39mg/L, and 0.00 - 0.10 mg/L in Aba and Umuahia respectively. All values were below the maximum limit by WHO and SON; indicating that the water samples were safe in terms of fluoride level. Fluoride in drinking water reduces dental decays,²⁸ but at a concentration above 1.5mg/L, it has an increasing risk of dental fluorosis and progressively higher concentrations can lead to risk of skeletal fluorosis.²⁹

Nitrates: Nitrates indicate the presence of fully oxidized organic matter. Nitrate value in bottled water ranged from 13.29 -14.54mg/L; and 22.09 -22.62 mg/L in Aba and Umuahia respectively. While in sachet water, nitrate value ranged from 20.41 -21.90 mg/L, and 13.91 -17.47mg/L in Aba and Umuahia respectively. These values were within the permissible limit of 50mg/L by WHO and SON. High nitrate concentration in drinking water causes blue baby syndrome in bottle-fed infants.³⁰

Conclusion

The study assessed the physicochemical properties of some brands of bottled and sachet water samples sold in Aba and Umuahia cities of Abia state. The study revealed that the parameters such as pH, TDS, TSS, EC, Chlorides, dissolved oxygen, fluorides and sulphates were within the permissible limit by WHO and SON for the bottled and sachet water except for pH of the sachet water in both cities, where there was a little variation. Hence, the companies should endeavor to fulfil the basic water quality standards. Also, there should be regular supervision of the companies by the regulatory agencies (NAFDAC, SON, NIS) to ensure quality of packaged water. In addition, awareness should be created to the public for boiling water before usage rather than wholly rely on belief of purity of bottled and sachet water.

Recommendations

The manufacturers should indicate the expiry date, batch number, manufacturing date and mineral compositions.

The regulatory agencies should make it necessary that all bottled and sachet water companies should have a standard laboratory for analysis of water before and after production.

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Conflicts of interest

This work does not involve any conflicts of interest for the authors.

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