Analysis of Some Physico-Chemical Parameters of Various Bottled Drinking Water Available in Kokrajhar Town, Assam, India

Mehdi Al Kausor, Biswajit Nath, Taznur Ahmed, Helena Brahma

Abstract*: Water in a plastic bottle was not a regular item on many consumers' shopping lists in few years ago. Now a days, thousands and millions of litres of packaged drinking water in bottles are sold everyday all over the globe. Considering various kinds of health issues, the quality of these bottled drinking water, therefore, should be monitored regularly. In this paper, we have tested some water quality parameters like pH, Electrical conductivity (EC), Total Dissolved solids (TDS), Alkalinity, Salinity, Ca-Hardness (CH), Total Hardness (TH), Sodium (Na^+), Potassium (K^+), Sulphate (SO_4^{2}) and Nitrate (NO_3^-) of fifteen different brands bottled drinking water available in the market of Kokrajhar Town, Assam, India. The target of this research work is to and to analyze these parameters in the water bottles sold commonly in the market and to check wheather the water quality parameters meets the prescribed BIS (Bureau of Indian Standards) and World Health Organisation (WHO) standards or not, so that we can make people of our society conscious about drinking such packaged drinking water. The result reveals that all the parameters used for analysis come within the permissible limit of BIS and WHO standards and are safe for drinking purpose.

***Index Terms*: Bottled drinking water, TDS, Hardness, Sulphate, Nitrate, Permissible Limit**

I. INTRODUCTION

"Water, water, everywhere, nor any drop to drink", is a common saying from the Greek myth of Tantalus. Water, a compound of H_2 and O_2 is a natural gift essential for the survival of all the living beings. It is available in many natural sources such as Rivers, Lakes, Ponds and some manmade sources like Well, Boreholes and Spring. In this era of pollution such water is contaminated with many undesirable substances as well as micro organisms and is not hygienic and safe for drinking purposes. Therefore, it is essential for the human beings to purify the water and supply under hygienic conditions for human drinking purpose. Now a days drinking water is available in the form of packaged drinking water manufactured under hygienic conditions. There are many types of packaged drinking water like purified water, mineral water, ground water and others. The bottled mineral water market is the most dynamically expanding branch of the non-alcoholic beverage sector [1]. The global bottled water market was valued at approximately USD 170.0 billion in 2014 and is expected to reach approximately USD 280.0 billion by 2020, growing at a CAGR of around 8.5% between 2015 and 2020. In terms of volume, global bottled water market stood at around 290.0 billion liters in 2014 [2]. The ever-increasing popularity of bottled water can be attributed to the consumers belief of getting safe, hygienic drinking water and perception of conferring higher social status, maintaining healthy lifestyles and also the effective marketing strategies by the manufacturers [3,4]. Many research groups [5-10] all over the world have investigated the physico-chemical parameters of the packaged drinking water manufactured by different companies. The major investigating parameters includes pH, Electical conductivity (EC), Total Dissolve Solid (TDS), Dissolve oxygen (DO), and Total hardness (TH) along with with Chloride (Cl^-), fluoride (F^-), Nitrate (NO_3^-), Sulphate (SO_4^{2-}), Phosphate (PO_4^{3-}), Arsanate (AsO_4^{3-}), Iron (Fe^{2+}), Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) and other heavy metal ions etc. In some cases it was found that the water quality meets the desired standards of WHO and other standard organizations and in some cases some parameters did not meet the desired quality standards. The distribution and storage process conditions for several weeks may adversely affect the quality of these packaged drinking waters [11]. Therefore, the quality of these bottled drinking water should be monitored regularly and periodically. In this work, physico-chemical analysis of bottled water found at Kokrajhar Town, Assam, India was done. The main target of this study was to analyze physically and chemically the different brands of bottled mineral water available in the market of Kokrajhar Town, Assam, India and to justify whether all the brands of bottled water sold commonly in the market meet the prescribed (Bureau of Indian Standards) BIS standards and (World Health Organisation) WHO standards or not, so that we can make people of our society conscious about drinking such packaged drinking water. The major water quality parameters considered for examination in this study are pH, Electrical conductivity (EC), Total Dissolved solids (TDS), Alkalinity, Salinity, Ca-Hardness (CH), Total Hardness (TH), Sodium (Na), Potassium (K), Nitrate (NO_3^-) and Sulphate (SO_4^{2-}).

II. EXPERIMENTAL SECTION

A. Sampling Area

Kokrajhar is located at 26.4^0N, 90.27^0E. It has an average elevation of 38 metres (124 feet). According to 2011 India census, Kokrajhar had a population of about 34,136.

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The climate of the region is sub-tropical in nature with warm and humid summer followed by cool and dry winter. Average temperature in summer is 27.64-31.67^{0}C and average winter 19.34-23.66^{0}C.

B. Sampling and Preservation

Fifteen different branded bottled drinking water samples of 500mL each were collected randomly from different grocery stores of Kokrajhar Town, Assam, India in the month of December, 2017 and were stored at room temperature (25-30^{0}C) until the samples were analyzed. To keep the brand names anonymous, the samples were coded from A to O.

C. Materials and Methods

For the determination of pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS) and Salinity Digital Water Testing Kit Model, No.161 (Electronics India) was used. Alkalinity, Ca-Hardness (CH), Total Hardness (TH) and Phosphate were measured by some ISO 9001: 2008 Certified Water Testing Kits and manual available therein. Sodium and Potassium (Na & K) were determined by a Digital Flame Photometer, Labtronics Model LT-66, ISO 9001: 2008 Certified and lastly, Sulphate (SO_4^{2-}) and Nitrate (NO_3^-) were determined by a Double Beam UV-VIS Spectrophotometer, Labtronics Model LT-2700. All chemicals were of analytical grade. Double distilled water were used to prepare all the required solutions. The instruments were caliberated prior to use.

(i) *Measurement of Alkalinity*

5ml of water sample was taken in the test bottle (No-1) and 5drops of Total Alkalinity Reagent-2 (TA-2) was added and mixed until an orange yellow colour develops. Total Alkalinity Reagent-1 (TA-1) was then added dropwise and shaked well after each drop until the colour changes from orange yellow to orange red. The no. of drops of TA-1 required for colour change was noted i.e;

Total Alkalinity = Number of drops x 5 (p.p.m. interms of $CaCO_3$)

(ii) Measurement of Calcium Hardness (Ca-H)

25ml of water sample was taken in the test bottle (No-1). 10 drops of Calcium hardness reagent-2 (CH-2) was added and mixed followed by 10 drops of Calcium Hardness reagent-3 (CH-3). Few specs of Calcium Hardness-1 (CH-1) was added and mixed until a distinct pink colour develops. For Hard/Soft water, Calcium Hardness reagent-4 (CH-4) was added and shaked well after each drop until the colour changes from pink to purple. The no. of drops of CH-4 required for colour change was counted.

Calcium Hardness = Number of drops x 5 (p.p.m. interms of $CaCO_3$)

(iii) Measurement of Total Hardness (TH)

25ml of water sample was taken in the test bottle (No-1). 10 drops of Total Hardness Reagent-2 (TH-2) was added and mixed. Few specs of Total Hardness Reagent-1 (TH-1) was added and mixed until a distinct pink colour develops. For Hard water, Total Hardness Reagent-3 (TH-3) is added dropwise and shaked well after each drop until the colour changes from pink to blue. The no. of drops of TH-3 required for colour change was counted. For Soft water, Total Hardness Reagent-4 (TH-4) is added dropwise and shaked well after each drop until the colour changes from pink to blue. The no. of drops of TH-4 required for colour change was counted.

Total Hardness = Number of drops x 2 (p.p.m. interms of $CaCO_3$)

(iv) Estimation of Sodium (Na^+) and Potassium $(K)^+$ ion

For the estimation of Na^+ and K^+ ion, a stock Na-K solution of 100 ppm is prepared by accurately weighing AR grade NaCl and KCl. From this stock solution Na-K solutions of 5, 10, 20, 40, 60, 80 ppm standard solutions are prepared. Now the concentrations of Na and K ions of these standards are recorded by the Flame Photometer. A calibration curve is drawn using concentrations as abscissa and instrument readouts as ordinate values. Then the concentration of sodium and potassium ions in the water samples are determined from the calibration curve.

(v) Estimation of Nitrate (NO3-)

For the estimation of NO_3^- concentration, at first Stock Nitrate solution is prepared by dissolving 0.3609 g KNO_3 in water and diluting it to 500ml; 1.00mL = 100µg NO_3^-or 100ppm. The intermediate nitrate solution is prepared by diluting 50ml stock nitrate solution to 500ml with water; 1.00 mL = 10.0µg NO_3^- or 10 ppm. Out of 10 ppm, four standard solutions were prepared of concentrations- 2ppm, 4ppm, 6ppm and 8ppm. After that 1N Hydrochloric acid solution is prepared. Now, to 50 ml clear sample, 1 ml HCl solution is added and mixed thoroughly. For the rest of the samples, the same process is followed. Then, NO_3^- calibration standards in the range of 0 to 7 mg NO_3^-mg/L is prepared by diluting to 50 mL the following volumes of intermediate nitrate solution: 0, 1.00, 2.00, 4.00, 7.00.....35.0mL. NO_3^- standards (i.e; 2ppm, 4ppm, 6ppm,8ppm) are treated in the same manner as the samples. Absorbance using distilled deionized water as the reference is read using a wavelength of 220 nm to obtain NO_3^- reading and a wavelength of 275 nm to determine inference due to dissolved organic matter by a double beam UV- VIS Spectrophotometer (Labtronics Model LT-2700) is done.

(vi) Estimation of Sulphate (SO42-)

For the estimation of SO_4^{2-} concentration, firstly, a conditioning reagent is prepared by mixing 25ml glycerol with a solution containing 15ml concentrated HCl, 150ml distilled water, 50ml isopropyl alcohol and 37.5 g NaCl followed by using a stock solution of 1000ppm sulphate out of which five 100ml standards with the concentrations of 10ppm, 20pm, 40ppm, 50ppm and 60ppm is created. For each of the standards, following procedure is used-10ml of standard and 10ml of distilled water is added to a 250ml Erlenmeyer flask. To it 5.0ml of the conditioning reagent is added and stirred gently. About 0.1-0.2 g of $BaCl_2$ is added to the flask. The contents of the flask are stirred for a minute. After the completion of the stir time, quickly and carefully the contents is poured into a spectrophotometer cell and allowed to stand for 5 minutes. While waiting, the Double Beam UV-VIS Spectrophotometer (Labtronics Model LT-2700) is zeroed at 420nm with distilled water and the absorbance of the standard is taken. After taking the absorbance for the remaining three standards, an absorbance vs. concentration curve,

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using the original concentrations of the standards is created. The concentration of sulphate in the 15 samples were estimated using the same procedure as used for the standards.

III. RESULTS AND DISCUSSION

The result of the analysis is shown in Table-1.

(i) *pH*

pH of water is given by –log[H^+]. It is actually the measure of acidic/ basic nature of water. From the analysis of all the 15 samples, it is found that the pH value ranges from 6.39-7.59. The lowest pH value of 6.39 is exhibited by sample 'B' and the highest pH value of 7.59 is exhibited by sample 'I'. The analysis of the pH values indicates that all the samples are in slightly acidic to slightly basic range which lies well within the permissible limits of BIS and WHO.

(ii) Electrical Conductivity (EC)

The electrical conductivity gives the measure of the ability to conduct electrical current through water. The EC of water arises due to the various ions present in it. The concentration and degree of ionization of the various solid substances present in water also contributes to the EC [12]. The EC is recorded in µS/cm at 25^0C as the ionization of the solutes depends on temperature. In the present study, EC value ranges from 60-220 µS/cm at 25^0C which is lower than the prescribed limits. From Table 1, it is observed that sample 'K' has the highest EC value of 220 µS/cm among all the samples whereas sample 'A' has the lowest EC value of 60 µS/cm.

(iii) Total Dissolved Solids (TDS)

In water TDS is the measure of the total dissolved minerals. More highly water is mineralized, higher is the TDS value. TDS of drinking water should not exceed 1000mg/L [13]. People suffering from kidney and heart disease should not drink water with high TDS value. The TDS value ranged between 0.03-0.16 mg/L. From Table 1, it is seen that sample 'G' has the lowest TDS value and sample 'J' has the highest TDS value.

(iv) Alkalinity

Alkalinity is the capacity of water to resist changes in pH that would make the water more acidic [14]. It roughly refers to the amount of bases in a solution that can be converted to uncharged species by a strong acid [14]. According to USEPA guidelines, higher level of alkalinity can cause embrittlement of boiler steel and boiled rice turns yellowish [15]. The alkalinity value ranges from 35 – 190 ppm. It is seen, from Table 1 that sample 'J' has the highest alkalinity value whereas sample 'G' has the lowest alkalinity value.

(v) Salinity

Salinity is the quantity of dissolved salt content of the water. The salinity value ranges from 0.03 - 0.09 ppm. From Table 1, sample B, C, G and M have the lowest salinity whereas sample 'J' have the highest salinity value.

(vi) Calcium Hardnedd (Ca-H)

Calcium hardness (Ca-H) of water is measured in terms of the amount of CO_3^{2-}, HCO_3^- and SO_4^{2-} of Calcium. In the present study Ca-H is found in the range 35 – 150 mg/L. Among all the samples, the minimum Ca-H is found in sample 'A' and the maximum Ca-H is obtained in sample 'B'. According to Sastry et al., 1998 [16] hard water plays a role in heart disease. The permissible limit of hardness in terms of Ca-H is 200 - 500 mg/L. So, from Table 1 it is observable that the Ca -H value for all the samples comes well within the permissible limit and can be considered as soft.

(vii) Total Hardness (TH)

Total hardness (TH) of water is measured in terms of concentration of calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions [17], in the form of CO_3^{2-} and HCO_3^- salts. From Table 1, it is observed that the total hardness values of the bottled waters are found in the range 12 - 60 mg/L. It was observed that sample 'D' contained lowest amount of TH and the highest amount was found in sample 'O'. Water having TH less than 75 mg/L is considered as soft, 75-150 mg/Li s considered as moderately hard, 150 - 300 mg/L is considered as hard and above 300 mg/L is considered as very hard in terms of concentration of calcium and magnesium. TH is an important criterion that decides the usability of water for domestic, drinking and many industrial purposes [18]. Water having TH beyond 300 mh/L can cause gastro-intestinal irritation. Since bottled drinking water in the present study contains TH value less than 75 mg/L, so they are classified as soft water.

(viii) Concentration of Ionic Constituents

Sodium and Potassium (Na^+ and K^+): Maximum limit of sodium in drinking water is > 20 mg/L but rarely cross this limit in some countries. Generally sodium salts are not toxic to human beings as it is readily excreted by kidneys. As a result no permissible limit is set by WHO and others. However if found higher than 200 mg/L, it may affect the taste of drinking water. Accordig to WHO report [19] excessive intake of sodium salts aggravates chronic congestive heart failure, and ill effects due to high levels of sodium in drinking-water have been documented in this report. Potassium is an essential element for humans. Potassium occurs in drinking water due to the potential use of $KMnO_4$ in water treatment processes and also due to the use of KCl as water softener in treatment devices. But, generally potassium occurs at very low level in natural drinking water and therefore, it do not posses any health affects. Where $KMnO_4$ is used in water treatment, concentrations of added potassium can be up to a maximum of 10 mg/L, but normally concentrations would be less than this (WHO). The concentration level of Na^+ and K^+ ions in the present study are well below the levels and will not pose any health affects. The concentration levels of the two cationic constituents are : 5.40 - 20.53 mg/L for Na^+ and 1.60 - 7.20 mg/L for K^+. Sample' K' has the highest concentration of Na^+ ion while sample 'A' has the lowest concentration of Na^+ ion. It is also found that the highest K^+ ion is possessed by sample 'K' and that of the lowest NO_3^- ion is possessed by sample 'M'.

Nitrate (NO_3^-) and Sulphate (SO_4^{2-}): Nitrate (NO_3^-) in drinking water can affect certain adults and small children. It may also cause methemoglobinemia or blue baby disease in infants (IS 10500-1991) and low birth weights have been

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Table 1: Physico-Chemical Parameters of Different Samples.

Sample ID	Brand	pH	Conductivity	TDS	Alkalinity	Salinity	Ca-H	TH	Na^+	K^+	NO_3^-	SO_4^{2-}
			(µS/cm)	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
1	A	7.28	60	0.07	80	0.04	35	20	5.4	1.85	0.54	10.77
2	B	6.39	110	0.04	55	0.03	150	18	16.2	5.6	1.64	48.64
3	C	6.75	80	0.05	40	0.03	60	16	13.14	2.1	0.53	27.74
4	D	6.75	102	0.07	75	0.05	100	12	15.3	4.85	1.64	51.21
5	E	7.27	140	0.09	70	0.06	75	18	18.65	6.3	2.08	66.92
6	F	7.4	105	0.07	65	0.04	65	14	12.8	4.8	1.57	50.43
7	G	7.16	90	0.03	35	0.03	85	14	8.35	3.25	0.59	18.27
8	H	6.56	130	0.08	90	0.05	70	18	17.4	5.2	1.61	70.84
9	I	7.59	130	0.09	70	0.05	50	30	16.86	4.9	1.55	63.56
10	J	6.89	110	0.16	190	0.09	45	16	15.3	4.85	1.54	52.16
11	K	7.04	220	0.07	85	0.04	70	50	20.53	7.2	2.67	98.42
12	L	6.73	120	0.07	85	0.04	55	18	14.82	5.8	1.71	63.01
13	M	6.85	70	0.05	65	0.03	35	14	8.65	1.6	0.55	57.78
14	N	7.35	120	0.12	150	0.08	135	18	16.47	5.1	1.54	54.17
15	O	7.51	108	0.12	115	0.08	70	60	15.62	5.15	1.53	18.4
BIS Permissible limit		6.5-8.5	-	500	200	-	300	200	-	-	100	400
WHO Permissible limit		6.5-8.5	300	500	120	-	500	500	-	-	10	200

Table 2: Pearson's Correlation for the Various Variable Parameters.

		pH	Conductivity	TDS	Alkalinity	Salinity	Ca-H	TH	Na^+	K^+	NO_3^-	SO_4^{2-}
pH	PCS	1	0.0529	0.3544	0.1418	0.3666	-0.2402	0.4024	-0.076	0.011	0.0232	-0.2042
Conductivity	PCS		1	0.1927	0.1676	0.1668	0.1756	0.5146	0.8297	0.851	0.8959	0.8019
TDS	PCS			1	0.9283	0.964	-0.116	0.2807	0.3797	0.3307	0.3477	0.1105
Alkalinity	PCS				1	0.8943	-0.0097	0.1755	0.2867	0.2844	0.2989	0.1402
Salinity	PCS					1	0.0634	0.2898	0.3884	0.3566	0.3373	0.0247
Ca-H	PCS						1	-0.083	0.3647	0.3986	0.2876	0.0556
TH	PCS							1	0.3855	0.3912	0.4221	0.0932
Na^+	PCS								1	0.8788	0.8863	0.7254
K^+	PCS									1	0.9665	0.6626
NO_3^-	PCS										1	0.7616
SO_4^{2-}	PCS											1

*** PCS = Pearsons Correlation Significance**

attributed to high nitrates in water. Sulphate (SO_4^{2-}) is considered as the least toxic ion and it has no ill affect to humans if found at the levels found in drinking water. The presence of high concentration of SO_4^{2-} in the drinking water may lead to dehydration, stomach complaints, and possibly diarrhea [20]. Generally, SO_4^{2-} has an adverse effect on the taste (bitter, medicinal taste) at levels lower than 200 mg/L. The concentration levels of the two anionic constituents are : 0.54 - 2.67 mg/L for NO_3^- and 10.77 - 98.42 mg/L for SO_4^{2-}. Sample' K' has the highest concentration of SO_4^{2-} ion while sample 'A' has the lowest concentration of SO_4^{2-} ion. It is also seen that the highest NO_3^- ion is possessed by sample 'K' and that of the lowest NO_3^- ion is possessed by sample 'C'.

(ix) *Statistical Analysis*

We have find the relationship between any two water quality parameters, suppose x and y, in terms of the Karl Pearson's correlation coefficient, r using the following equation-

$$r = \frac{N\Sigma xy - (\Sigma x)(\Sigma y)}{[N\Sigma x^2 - (\Sigma x)^2][N\Sigma y^2 - (\Sigma y)^2]}$$

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Where, N = No. of pairs of scores, Σxy = Sum of the product of paired scores, Σx = sum of x scores, Σy = sum of y scores, Σx^2 = sum of squared x scores, Σy^2 = sum of squared y scores. The statistical data using Pearson's correlation for various water quality parameters are shown in table-2. It is observed that significant correlation ($r > 0.5$) is found in the following parameters- pH with EC, Conductivity with TH, Na^+, K^+, NO_3^- and SO_4^{2-} While the ionic constituents were significantly correlated with one another. Positive correlation was found in 39 pairs (≈ 87%) and negative correlation was found in 6 pairs (≈ 13%) of parameters.

IV. CONCLUSION

In this study, fifteen brands of bottled water found at Kokrajhar Town, Assam, India were assessed for their physico-chemical analysis. After performing a series of experiments, it is observed that all the physical and chemical parameters used for analysis come within the permissible limit of WHO standards and BIS standards. Although, all the bottled water samples has slightly higher value of pH which may arise due to water treatment process. Infact, all the values obtained after investigation are lower than that of the maximum permissible levels of the previous standards. However, the chemistry of bottled water may change during transportation or storage, particularly by the influence of light or sunlight on the container. Also the chemical properties of the bottled water is changed by the extend of period of time they are kept. It is therefore suggested that quality of such commercial bottled drinking water should be monitored time to time and proper care should be taken in hand for the maintenance of the water quality of these bottled drinking water.

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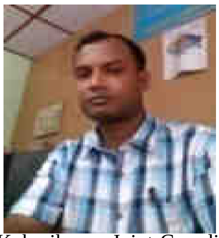

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