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Assessment of Bottled Drinking Water Quality in Baghdad Local Market by Some Chemical and Biological Parameters

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Abstract

The aim of this work is to study different parameters of bottled drinking water that affect the health of people of Baghdad city. To perform this target, seventeen bottled samples were collected from local markets which were different bottles size and trade markets. The samples were analyzed physical, chemical and biological factors that influence water quality of the bottled water. The physical and chemical tests of bottled water showed that the mean value of pH ranged from 6.96-8.5, Total Dissolved Solids (TDS) 8-166 ppm, Total Hardness (TH) 22-178 ppm, Calcium (Ca^{++}) 0.0-35 ppm, Magnesium (Mg^{++}) 0.0-30 ppm, Chloride (Cl^{-}) 0.0-27 ppm, sodium (Na^{+}) 0.0-25 ppm, potassium (K^{+}) 0.0-4.5 ppm, Electrical Conductivity (Ec) 16-332 µs/cm. All samples were within the permissible limits for Iraqi criteria and standards for bottled water. The biological parameters include: total plate count, total coliform, fecal coliform, *E.coli* and yeast& fungi. The failure percentages of samples were 23.5, 11.7, 11.7, 11.7 and 11.7% respectively.
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Keywords: bottled drinking water, physical parameters, chemical parameters biological parameters, national Iraqi standard.

Introduction

The availability of good quality drinking water is very important for prevention of diseases and for maintaining the quality of life for humans, [1]. Water quality deals with the physical, chemical and biological characteristics in relation to all other hydrological properties, [2].

The human dietary requirement for water is estimated to be approximately two liters per day for a mean adult. The regular intake of adequate amounts of water is essential in the maintenance of good health and well-being, [3]. However, the most important attribute of drinking water that has to be assured and maintained is its safety and quality to ensure that it is safe for human consumption, [4].

The nature and form of drinking-water standards may vary among countries and regions. There is no single approach that is universally applicable. Approaches that may work in one country or region will not necessarily transfer to other countries or regions. It is essential that each country reviews its needs and capacities in developing a regulatory framework, [5].

It is very essential and important to test the water before it is used for drinking. Water must be tested for different physical and chemical parameters. Selection of parameters for testing of water is solely depends upon for what purpose we going to use that water and what extent we need quality and purity. Water does contain different types of floating, dissolved, suspended and microbiological as well as bacteriological impurities, [6].

Materials and methods

The physical and chemical parameters assessed in this study were**:**

pH

pH values were measured by wtw 7110 PH.

Total Dissolved Solids (TDS) and (Ec) Electrical Conductivity

Ec and TDS values were measured by wtw 7110 Ec.

Total Hardness as $CaCO_3$

A buffer solution (about 1-2 mL of weak alkaline (NH_4)) was added to 50 mL of water sample. Usually 1 mL will be sufficient to give a pH of 10.0 to 10.1 then an appropriate amount of dry-powder indicator (Erichrome Black T) formulation was added, titrated slowly against standard EDTA, with continuous stirring, until the last reddish tinge

disappears. Add the last few drops at 3 to 5 seconds intervals. At the endpoint the solution normally is blue, [7].

Calcium (Ca^{+2} as $CaCO_3$)

A strong alkaline (about 2 mL of ((NaOH))) was added to 50 mL of water sample, (usually 2.0 mL NaOH solution will be sufficient to produce a pH of 12 to 13) then an appropriate amount of dry-powder indicator (Meroxide) was added, the mixture was titrated slowly against standard EDTA, with continuous stirring, at the endpoint the colour will be purple, the endpoint was checked by adding 1 to 2 drops of titrant in excess to make certain that no further color change occurs, [7].

Magnesium (Mg^{+2} as $CaCO_3$)

A calculated magnesium was estimated as the difference between hardness and calcium as CaCO3, [7] by equation:

$$Mg\ (mg/L) = [(\text{Total Hardness as } CaCO_3) - (Ca^{+2} \text{ as } CaCO_3)] \times 0.243$$

Potassium (K^+)

Potassium was Determined in either a direct-reading or internal-standard type of flame photometer at a wavelength of 766.5 nm.

Sodium (Na^+)

Sodium was determined by flame emission photometry at 589 nm.

The microbial method

The microbiological parameters assessed in this study were: the total plate count (T.P.C)/ 1ml by pour plate method, the most probable number of total coliform (M.P.N. of TC)/ 100 ml by multiple tube fermentation, the most probable number of fecal coliform (M.P.N. of FC)/ 100 ml by multiple tube fermentation, the most probable number of *E. coli* (M.P.N. of *E. coli*)/ 100 ml by multiple tube fermentation. In addition, the yeast & fungi / 100 ml by filtration method. These parameters are frequently used as indicators of the bacteriological quality of drinking and bottled water, and numerous bacteriological studies of drinking water employ a combination of two or more of these tests [8, 9, 10].

Results

Physical and chemical results

pH: The maximum and minimum pH values were 8.5 and 6.96 respectively, with the mean of pH value for all samples 7.7 Table (1). All samples were showed acceptable pH value when compared with the national Iraqi standard for bottled water (6.5-8.5) [11] and International Bottled Water Association (IBWA) [12,13].

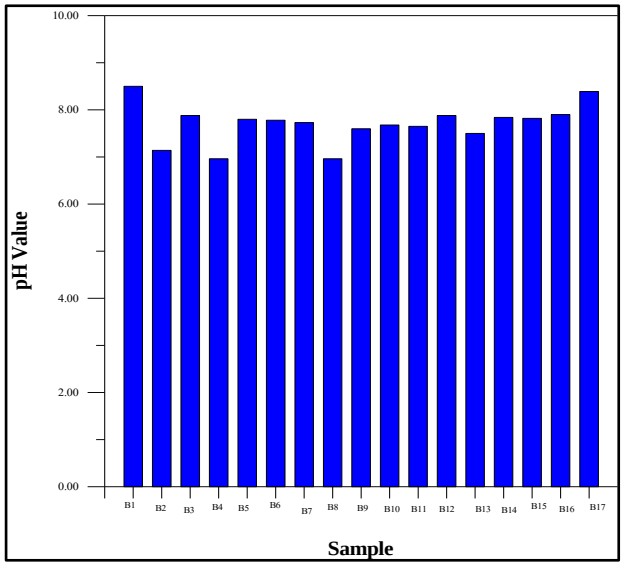

Fig.(1) pH values as a function of water samples.

1- Total dissolved solids (TDS):

The maximum and minimum TDS value were 166 and 8 ppm respectively, with the mean value 58.79 ppm Table (1). All samples showed acceptable TDS value compared with national Iraqi standard for bottled water (0-250) ppm**.**

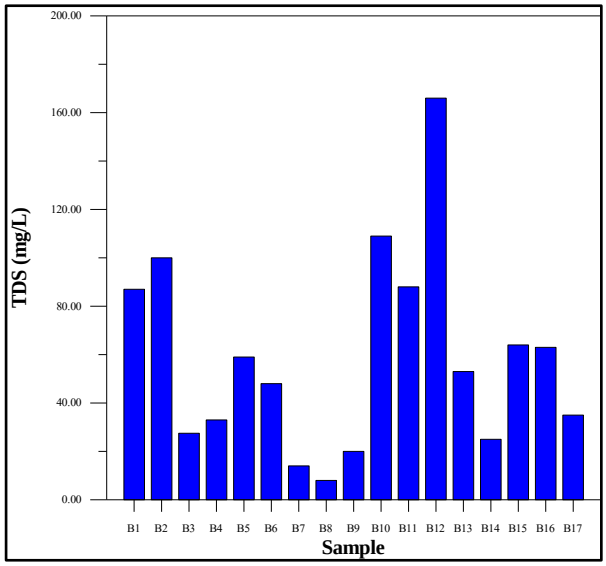

Fig.(2) TDS values as a function of water samples.

2- Total Hardness (TH) as $CaCO_3$:

The maximum and minimum TH values were 178 and 22 ppm respectively, with mean value 76.69 ppm Table (1). All samples showed acceptable TH value to the national Iraqi standard for bottled water (0-300) ppm.

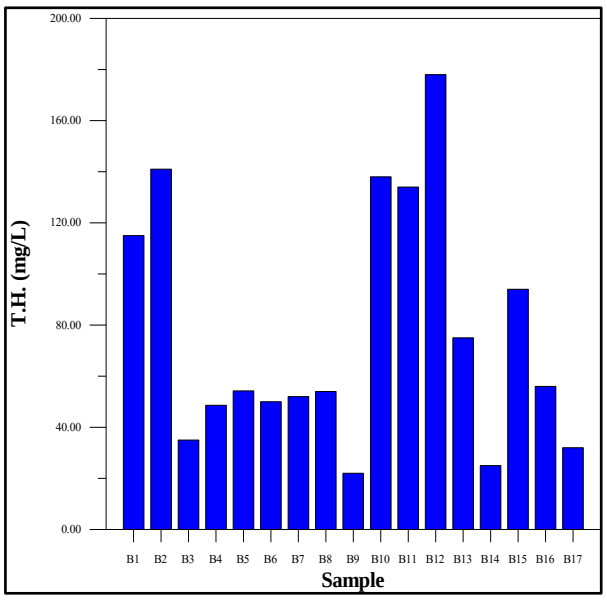

Fig.(3) Concentration of TH as $CaCO_3$ (mg/L) as a function of water samples.

3- Calcium (Ca^{+2} as $CaCO_3$):

The maximum and minimum Ca values were 35 and N.D ppm respectively, with mean Ca value 10.58 ppm Table (1). All samples were acceptable Ca value compared with national Iraqi standard for bottled water (0-75) ppm.

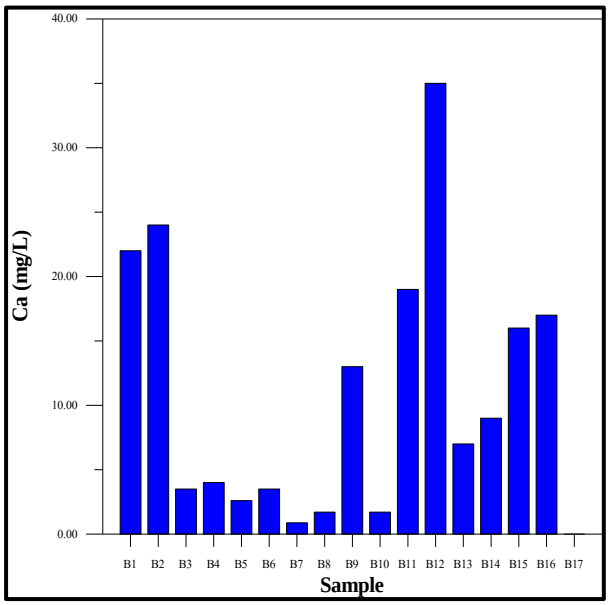

Fig.(4) Concentration of Ca as $CaCO_3$ (mg/L) as a function of water samples.

4- Magnesium (Mg^{+2} as $CaCO_3$):

The maximum and minimum Mg values were 30 and N.D ppm respectively, with the mean of Mg value 13.02 ppm Table (1). All samples were acceptable Mg value compared with national Iraqi standard for bottled water (0-30) ppm.

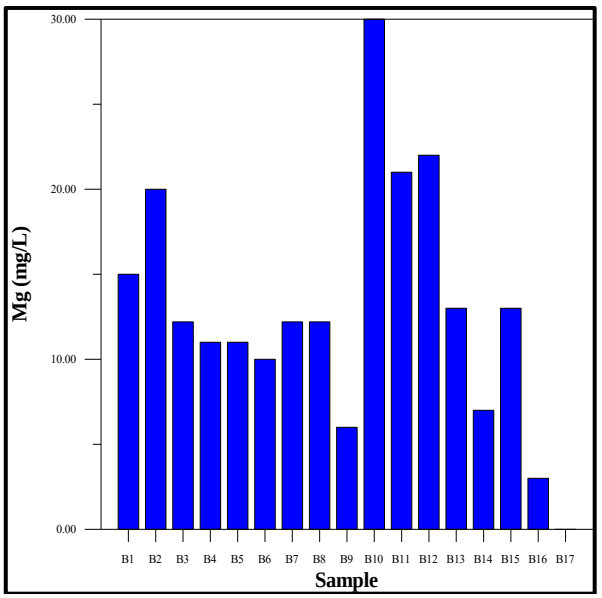

Fig.(5) Concentration of Mg as $CaCO_3$ (mg/L) as a function of water samples.

5- Cl:

The maximum and minimum Cl values were 27 and N.D ppm respectively, with the mean of Cl value 8.4 ppm Table (1). All samples showed acceptable Cl value compared with national Iraqi standard for bottled water (0-250) ppm.

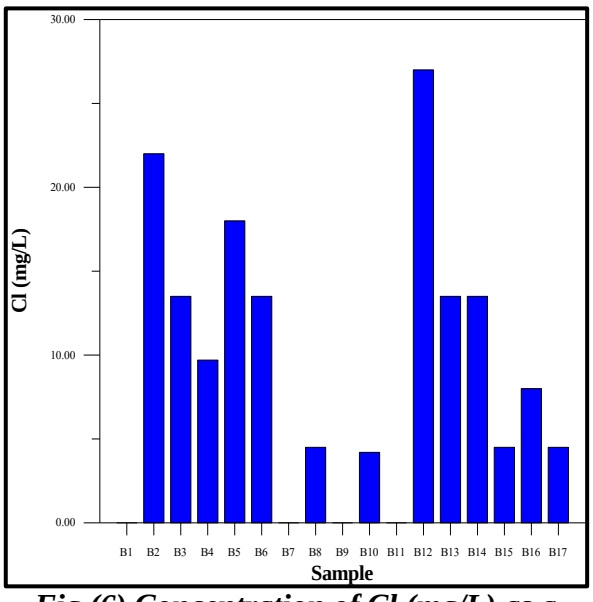

Fig.(6) Concentration of Cl (mg/L) as a function of water samples.

6- Sodium (Na^+):

The maximum and minimum Na value were 25 and N.D ppm respectively, with the mean of Na value 8.04 ppm Table (1).

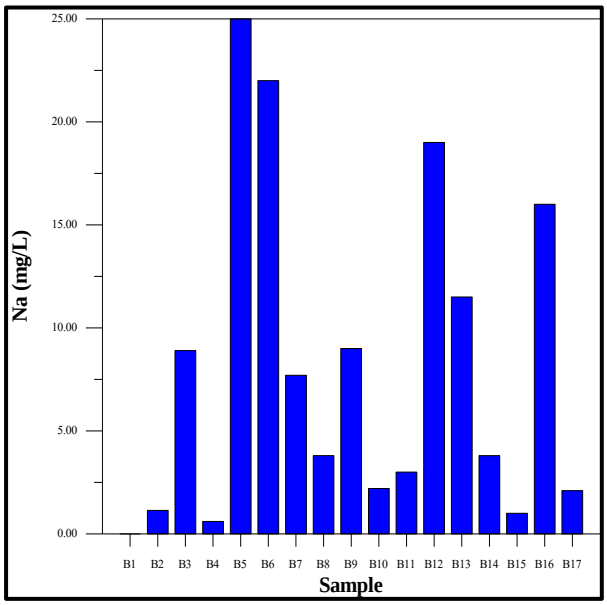

Fig.(7) Concentration of Na (mg/L) as a function of water samples.

Potassium (K^+):

The maximum and minimum K value were 4.5 and N.D ppm respectively, with the mean of K value 0.86 ppm Table (1).

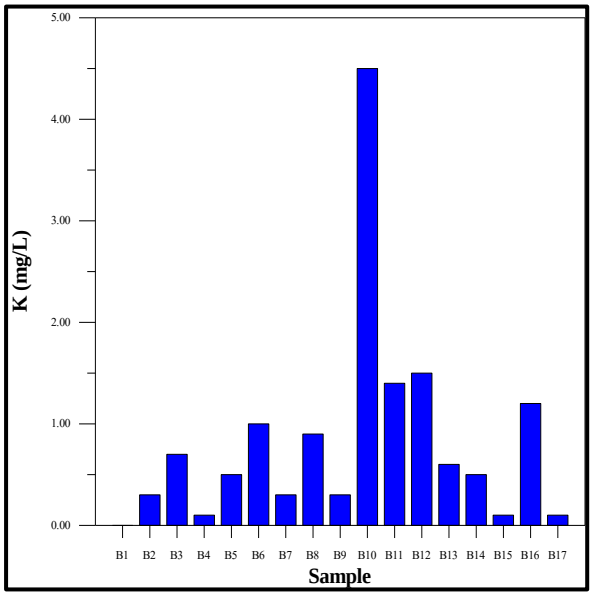

Fig.(8) Concentration of K (mg/L) as a function of water samples.

7- Ec:

The maximum and minimum Ec values were 332 and 16 µs/cm respectively, with the mean of Ec value 117.5 µs/cm Table (1). All samples showed acceptable EC value compared with national Iraqi standard for bottled water (500-1000) µs/cm.

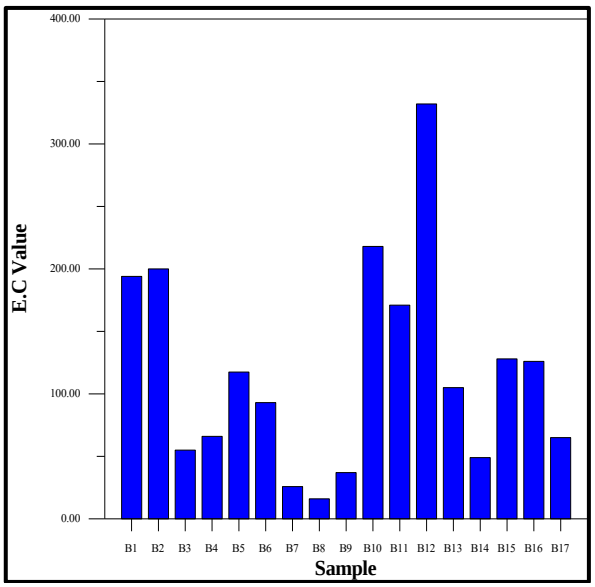

Fig.(9) Ec values as a function of water samples.

When compared the result with national Iraqi standard for bottled water within allowed limits so it compatible with previous studies [14-15] some of inorganic toxic like heavy metals and organic matter most studied to give a clear review for bottled drinking water and most give it a permissible limits in national Iraqi standard for bottled water, the maximum value showed that bottled volume 20 L give upper of others but also under national Iraqi standard for bottled water.

Microbial Results

The results of microbiology observed that five samples were exceeding the allowable limits according to Iraqi Criteria and Standards for bottled drinking water with failure percentage 29.2 % from all examined samples. These results included TPC / 1 ml, M.P.N of total coliform / 100 ml, M.P.N of fecal coliform / 100ml, M.P.N of *E. coli* / 100 ml, yeast & Fungi / 100 ml with failure percentage 23.5, 11.7, 11.7, 11.7 and 11.7 % respectively Table (2). These failure percentage occurred especially of the large bottled container may due to re-used of the container and don't care about cleaning of the container.

The national Iraqi standard for bottled water doesn't contain permissible limits to yeast and fungi but the WHO criteria limit is zero. In this study two of bottled sample were

contain yeast and fungi therefore must examine this test as routine analysis for bottled drinking water.

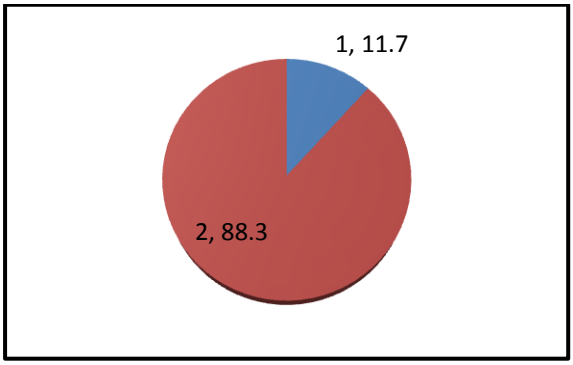

Fig.(10) Failure percentage of M.P.N of T.C/100 ml from all examinated samples.

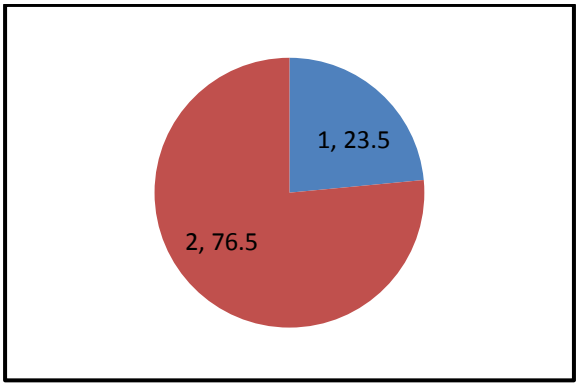

Fig.(11) Failure percentage of T.P.C./ 1 ml from all examinated samples.

Table (1)
The Mean, maximum and minimum value of pH, Ec, total hardness, Ca, Mg, Cl, Na, K and TDS in bottled water samples.

Sample	PH	EC	T.H	Ca	Mg	Cl	Na	K	TDS
B1	8.5	194	115	22	15	N.D	N.D	N.D	87
B2	7.14	200	141	24	20	22	1.14	0.3	100
B3	7.88	55	35	3.5	12.2	13.5	8.9	0.7	27.5
B4	6.96	66	48.6	4	11	9.7	0.6	0.1	33
B5	7.8	117.4	54.2	2.6	11	18	25	0.5	59
B6	7.78	93	50	3.5	10	13.5	22	1	48
B7	7.73	25.8	52	0.87	12.2	N.D	7.7	0.3	14
B8	6.96	16	54	1.7	12.2	4.5	3.8	0.9	8
B9	7.6	37	22	13	6	N.D	9	0.3	20
B10	7.68	218	138	1.7	30	4.2	2.2	4.5	109
B11	7.65	171	134	19	21	N.D	3	1.4	88
B12	7.88	332	178	35	22	27	19	1.5	166
B13	7.5	105	75	7	13	13.5	11.5	0.6	53
B14	7.84	49	25	9	7	13.5	3.8	0.5	25
B15	7.82	128	94	16	13	4.5	1	0.1	64
B16	7.9	126	56	17	3	8	16	1.2	63
B17	8.39	65	32	N.D	N.D	4.5	2.1	0.1	35
Mean	7.7	117.5	76.69	10.58	13.02	8.4	8.04	0.86	58.79
Maximum	8.39	332	178	35	32.8	27	25	4.5	166
Minimum	6.96	16	22	0	0	0	0	0	8

Table (2)
The biological results of TPC, TC, FC, E. coli, yeast and fungi and the Failure percentage of bottled water samples.

Sample	T.P.C./ 1ml	M.P.N of T.C/100 ml	M.P.N of F.C/100 ml	M.P.N of *E. coli*/100 ml	Yeast &fungi/ 100ml	Resultes
B1	Zero	Zero	Zero	Zero	Zero	Acceptable
B2	Zero	Zero	Zero	Zero	Zero	Acceptable
B3	Zero	Zero	Zero	Zero	Zero	Acceptable
B4	**170**	Zero	Zero	Zero	**150**	Un acceptable
B5	Zero	Zero	Zero	Zero	Zero	Acceptable
B6	Zero	Zero	Zero	Zero	Zero	Acceptable
B7	Zero	Zero	Zero	Zero	Zero	Acceptable
B8	Zero	Zero	Zero	Zero	Zero	Acceptable
B9	Zero	Zero	Zero	Zero	**50**	Un acceptable
B10	Zero	Zero	Zero	Zero	Zero	Acceptable
B11	Zero	Zero	Zero	Zero	Zero	Acceptable
B12	Zero	Zero	Zero	Zero	Zero	Acceptable
B13	Zero	Zero	Zero	Zero	Zero	Acceptable
B14	**75**	Zero	Zero	Zero	Zero	Un acceptable
B15	Zero	Zero	Zero	Zero	Zero	Acceptable
B16	**110**	**>23**	**>23**	**>23**	Zero	Un acceptable
B17	**20**	**2.2**	**2.2**	**2.2**	Zero	Un acceptable
Failure percentage	**23.5%**	**11.7%**	**11.7%**	**11.7%**	**11.7%**	**29.4%**

Acknowledgements

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