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Effect of Storage Condition on Some Bottled Water Quality in Erbil City, Kurdistan Region-Iraq

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Abstract: This study was conducted for assessing the effect of temperature and sunlight exposure on the suitability of four types of bottled water (Al-Hayat, Life, Kani, and pearl) for drinking purposes in respect to physicochemical properties (EC, TDS, pH, Alkalinity, Hardness, Ca+2, Mg+2, Na+, K+, and No3-2). The physicochemical variables of the bottled water measured in this work compared with manufacture's labeling reported on the bottles and were compared with guideline value of WHO and IBWA standard. The change of physicochemical characteristic investigated when the bottled water exposed to sunlight or storage at different temperature. According to WHO and IBWA, the quality of all bottled waters was suitable for drinking purpose for all variables that studied.

Keywords: storage, Condition, Bottled water, Erbil, Kurdistan, regions

I. Introduction

Water is an essential for life on the earth, is the most widely distributed nongaseous substance in nature. Because of water important, the pattern of human settlement throughout history has often been determined by its availability [1]. The composition of water varies widely with local geological condition, neither ground water nor surface water has ever been chemically pure, since water contains small amount of gases, mineral and organic matter of natural origin [2]. Water is the single abundant substance in the human body, making up to 60% of an adult's weight and up to 80% of an infant's weight [3]. Bottled water can be defined as any potable water that is manufactured, distributed or offered for sale, which is sealed in food-grade bottles or other sanitary container and intended for human consumption [4]. Bottled water is the fastest growing drink choice and its consumption in the world increased by average 10%, therefore it became the most dynamic sector of all food and beverage industry due to accessibility, relatively low cost, better taste, and lower level of impurities (EPA) [5]. Bottled water comes from various sources like spring and mineral water are drawn from underground water sources such as bore holes or springs, they differed according to their composition and content in minerals. Other bottled water can be either water from springs and wells or drink water from the distribution system [6]. Bottled water consumption has been steadily growing up the last three decades in a global level. The main reason for this rapid consumption was the lack of safe and accessible drinking water and the taste of chemicals, particularly chlorine, used to purify tap water [7]. The aim of this study is evaluating the physicochemical water quality of some bottled water that is available in Hawler city, Kurdistan region of Iraq. Consumptions of the results to standards as well as to reported label values are presented and the effects of temperature and sunlight on the quality of these bottled waters.

II. Description of the areas

The study was conducted in Erbil city. The studied area (Erbil city) covers about 70 km² between latitude 36° 09' to 36° 14' N and between longitude 43° 58' to 44° 03' E [8]. Four bottled waters were collected in various shops in the city on two replications during November-2011 to February-2012. The present study was carried out during a 4 month period on a total of 72 natural bottled water samples of 4 commercial brands produced in Iraq and Turkey that are available in Erbil city to consume. The water type and source of each is represented in tables (1 and 2).

Table (1) the bottled water type and source of each brand

Bottled water brands	Water type	Source of water
Al-Hayat	Natural spring water	Adana-Turkey
Life	Natural spring water	Duhok-Iraq
Kani	Natural spring water	Erbil-Iraq
Pearl	Purified water	Iraq

Table (2) physicochemical variables in bottled water during c studied period

Site number	Al-Hayat		Life		Kani		Pearl	
Parameters	M	L	M	L	M	L	M	L
pH	7.77	7.55	6.66	7.2	7.12	7.4	6.64	5.0-7.0
EC	133.00	NI	160.50	NI	366.00	NI	32.00	NI
TDS	85.12	NI	102.72	NI	334.20	NI	20.48	>10
Alkalinity	80.00	NI	55.00	NI	135.00	NI	20.00	NI
Hardness	85.00	NI	80.00	10	220.00	NI	20.00	NI
Ca+2	24.05	19.37	24.05	24.2	72.14	70	4.01	NI
Mg+2	6.07	4.02	4.86	4.4	9.72	10	2.43	NI
Na+	59.50	2.2	47.15	NI	14.95	3.1	14.95	0
K+	0.30	>0.2	0.60	NI	1.85	1.5	1.85	NI
NO3	4.35	NI	2.25	0.5	11	10.5	0.25	0

M: measured

L: labled

NI: not included

III. Materials and methods

Four brands of bottled water (Al-Hayat, Life, Kani and Pearl) were collected from different supermarkets with Hawler city in Kurdistan region of Iraq for period of November 2011 to February 2012. Each brand name and origin are given in table (1 and 2). EC, TDS, pH, Alkalinity, Total hardness, Ca+2, Mg+2, Na+2, K+ and No3-2 were analyzed using standard method describe in[9].

IV. Results and discussions

Generally any marketed bottled water should be identified, and its label should expose the following information: brand name with proper type of bottled water, source of water, major ionic composition, contained volume, bottling and expiry dates in text; company name, address and country of produce. Additionally any employed treatment strategies should be mentioned on the identification label [10]. As shown in Table 1, Most of water brands produced in Kurdistan region and other country does not expose the necessary information.

In the present work the results of physicochemical properties were compared with the guideline value of World Health Organization [11] and International Bottled Water Association [3] standards. Additionally the results of the physicochemical properties measured in this work compared with the reported label values for all bottled water samples (Table.3).

Result effect of sunlight and temperature on physicochemical properties for four bottled water during December -2011 to February -2012 , that collected in Erbil City from different shops Where shown in (Figures 1 to 10 and Tables 4 to 11) ,and compare the result of this properties with World Health Organization (WHO) and Bottled Water Association (IBWA) standard as shown in (table 3).

pH numerical expression of hydrogen ion concentration indicate in degree of acidic and alkaline [12]. The pH values for all samples from study area fluctuated between (7.0 to 8.1) the pH valued showed remarkable difference between PH determined and the reported on the labels , the limited of PH value for drink water according to IBWA is specified as 6.5 - 8.5 the PH of water show slightly alkaline trend .generally PH of water is in flounced by geology of catchment area and buffering capacity of water [7] similar conclusion by [7, 13& 14].

Electrical conductance is a numerical expression of the ability of an aqueous solution to carry an electric current , this ability depend on the presence of ions ,The electrical conductivity of bottled water sample showed with short variation , which range from (21- 430.5 ms/cm) and all samples are with the WHO and IBWA limit for drink water . This fluctuation in EC is attributed to soil source. Lithology and Geological origin of source that produced of each bottled water [15], conductivity is the important water quality measurement because it gives a good idea of amount of dissolved material in the water [16]. the difference value of EC of bottled water samples may be due to the reason of the composition of water of different source area . The diversity of soil composition different mineral rock , the increase in conductivity of water accompanied by increase the total dissolved solid ,this mean that there close relationship between EC and TDS [13], similar conclusion by [7, 13& 14]. Total dissolved solids is the term

used to describe the inorganic salt and small amount of organic matter present in water like calcium, magnesium, sodium, potassium cation, and addition carbonate, chloride, bicarbonate, sulfate, and nitrate [2 and 11], total dissolved solid (TDS) values of sample varied between (13.44 – 743.6 mg/l). these values were within the WHO and IBWA standards. there are remarkable differences between TDS values measured in this work with that of reported on labels, in the study of the reasons of clear variation in TDS values where noted throughout all bottled water brand may be due to the natural resource from which the water bottled and TDS originated, or from urban run-off and geology of the area [2], similar conclusion by [7, 13& 14].

Alkalinity is measure of water capacity to neutralize a strong acid. total alkalinity is generally associated with the presence of carbonate, bicarbonate and hydroxide and alkalinity is measure amount of alkaline materials in the water. mean level of alkalinity in bottled water ranged between (20 – 455 mg CaCO₃/l) this fluctuation in alkalinity may be related to type and amount of rocks like sedimentary rock, especially calcareous rock, which are rich in carbonate, have a high weather able silicate have a high base saturation and are well buttered and generally give rise to circumvented (pH =7) or slightly alkaline hard water (PH of 7.5- 8.5)[17]. similar conclusion by [7, 13& 14]. Hardness is caused by metal cations such as calcium, but infect all divalent and polyvalent cations cause hardness they react to certain anions such a carbonate and sulfate to form a precipitate. monovalent cations such as sodium do not effect hardness. strontium, ferrous iron, and magnesium are usually such minor component of hardness that they are generally ignored, with the total hardness taken to the sum of calcium and magnesium concentration [18]. result of total hardness in percent study fluctuation from 20 mg CaCO₃/l record in Pearl water and maximum of 300 mg CaCO₃/l in Kani water, this mean the hardness in bottled water varied from soft to moderately hard water, this may be due to source, geographical and soil properties of the catchments area, various human activities as well as climate condition have been to influence on hardness value in any water source [19 and 20] similar conclusion by [7, 13& 14].

Calcium and magnesium two of many inorganic substance are responsible for creating hard water [21]. Calcium and magnesium regarded important major cations in water. calcium and magnesium concentration in bottled water varied from 4.01 - 94.1mg/l and 0 - 119.84 mg/l respectively, this variation of concentration of both cations may be related chemical weathering of rock and mineral containing of each ion such as sedimentary rock, limestone, dolomite, gypsum, aragonite, mineral of igneous rock feldspar, amphibole, and pyroxene and pH of each source [20& 22], generally calcium ions level over the level of magnesium ions in this investigation, this case related to chemical properties of the soil and geological information of water source [23] similar conclusion by [7, 13& 14].

Sodium is the principal cation in hydrosphere, and is the key element in bottled water and essential for health, high level of sodium cause problem and low level cause diet is often advised, sodium ion concentration ranged between 0.1 - 59.5 mg/l.

Potassium although it is an essential element, the body find to difficult to deal with excess potassium resulting in kidney stress [24]. In the present study the potassium ion concentration ranged between 0 - 1.9 mg/l. sodium concentration in bottled water more abundance than potassium, this is due to that b potassium enters in to the structure of certain clay mineral during the weathering processes and the higher resistance to weathering processes and higher resistance to weathering of many potassium mineral in relation of sodium minerals that less resistance to weathering therefore sodium value more than potassium value. the difference between sodium concentration and potassium value in different bottled water in this study may be considered to geology and soil formation of the drainage basin, atmospheric deposition, human activity, and also influence the ionic composition by the chemical composition of ground water and atmospheric deposition of solute through wet and dry precipitation [25]. Similar conclusion by [7, 13& 14].

Nitrate is an essential source of nitrogen and available for plant which more stable in ground water either than nitrite or ammonium, this may be due to that nitrite is the final step in oxidation of ammonia and other nitrogen compound[26]. nitrate is the more stable oxidized from of nitrogen compound in most environmental media [11], nitrate is found in all brands, at the concentration between (0- 11 mg/l). three brands of bottled water showed the concentration of nitrate is more than that recorded on labels [9]. nitrate leaching in to water table throughout the year. also the rate of leaching depend on some factor's such as geology, soil type, rainfall pattern and crop utilization, rate of nitrogen, microbial concentration, fertilizers application, nitrate very soluble and is dissolved by rain fall and percolations deeper in to the soil it meet an impermeable layer such clay by side away migration throughout the soil until it fined away into the ground [27 & 28]. Similar conclusion by [7, 13& 14].

Effect of sunlight exposed: The Measurement of physicochemical properties of sample has been carried out every seven days for two weeks after exposing bottled water under natural sunlight. The results tabulated in (Figures 1 to 10), clearly indicate the increasing of the values of EC, TDS, hardness, calcium and magnesium with increasing of sunlight exposure time. While the values of pH, alkalinity, sodium, potassium and nitrate were decreased with increasing of sunlight exposure time. The increasing of EC (from 366 to 374 $\mu\text{S}/\text{cm}$) and TDS (from 234.4 to 273.6 mg L^{-1}) and hardness and calcium and magnesium from (85-105 mgCaCO_3/L) and (24.05-26.05 mg/L) and (6.07-9.87 mg/L) respectively, with sunlight exposing may be due to the leaching of ions and metals from plastic bottled to the water. Leaching of metals from plastic bottles to the water was evaluated by many researchers. [29], [30]. On the other hand, the increasing of EC and TDS were companied by increasing of ions concentration with sunlight exposure time.

The pH and alkalinity values of the bottled water were decreased from 7.12 to 7.02 and 195-160 mgCaCO_3/L respectively when exposed to sunlight for 14 days. This can be ascribed to the oxidation of organic compounds through the photo degradation by sunlight which producing such compounds like phthalate ester, halo acetic acids and acetaldehyde [31].

These variation physico-chemicals characteristics of bottled water under , this may be due weather (some days are clouds and other day sun appear or is rain), resistance and sensitive of bottled water , origin and geology of each bottled water, or may be due to degradation of plastic bottle due to different temperature ,resistance and sensitive of each plastic bottled water to different temperatrue [7].

Effect of Temperature: Thermal degradation of polymers is ‘molecular deterioration as a result of overheating’. At high temperatures the components of the long chain backbone of the polymer can begin to separate (molecular scission) and react with one another to change the properties of the polymer.

Several experiments were carried out under different temperature condition for 14 days to deduce the effect of temperature on the physicochemical properties values of bottled water. During 14 days of sample storage under 25 $^{\circ}\text{C}$, no significant change of physicochemical properties was observed .While, when the temperature raised to 35 $^{\circ}\text{C}$, all physicochemical properties values started change with increasing the time of storage .This increasing was observed more remarkably when the temperature raised to 45 $^{\circ}\text{C}$ as shown in (Tables 6-11). The changing trend of the physicochemical properties values with increasing of temperature can be ascribed to the occurring of plastic thermal degradation. Thermal degradation is temperature dependent and it occurs more rapidly at higher temperatures [32]. It is reasonable to believe that the temperature may have similar effect as the sunlight exposing on the physicochemical properties change.

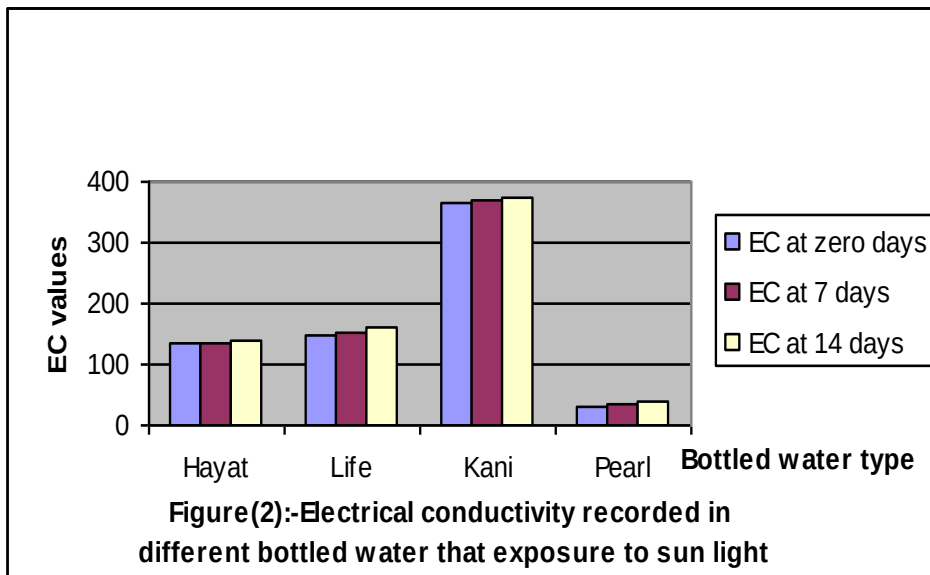
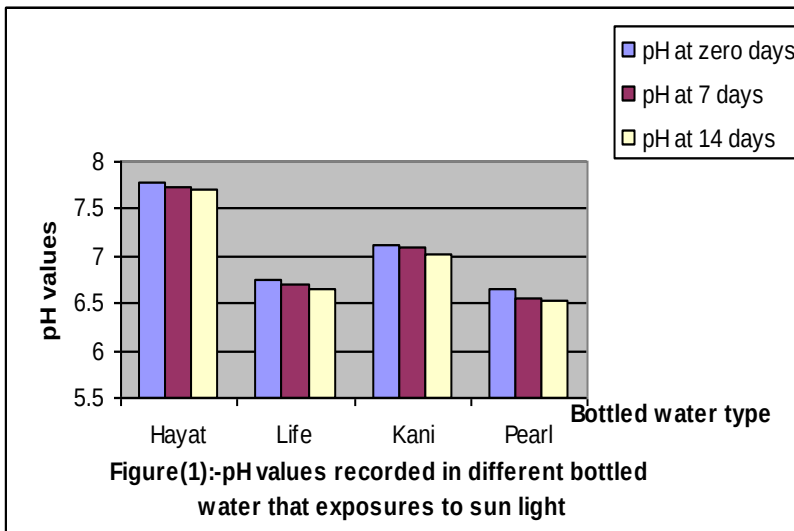
V. Conclusions

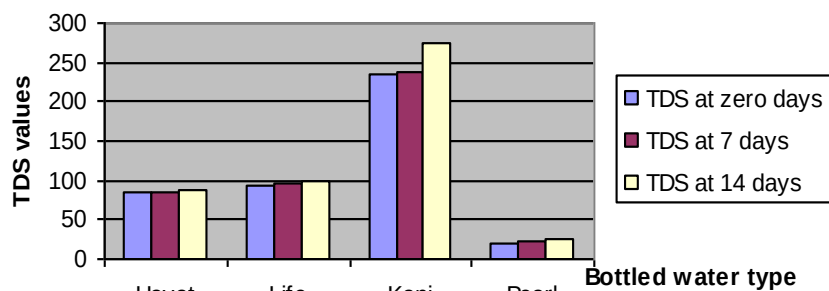
On the bases of our results we can conclude the following:

- 1-The concentration levels of various physiochemical parameters in the studied bottled water types did not exceeded the international guidelines for drinking water.
- 3-The information reported on the label dose not represent the real values of physicochemical properties.
- 4- Variations of physiochemical properties were found between the bottled water brands.
- 5- The storage of bottled water in condition above 35 $^{\circ}\text{C}$ or exposure to sunlight leads to increasing the values of some variables and decreasing others variables.

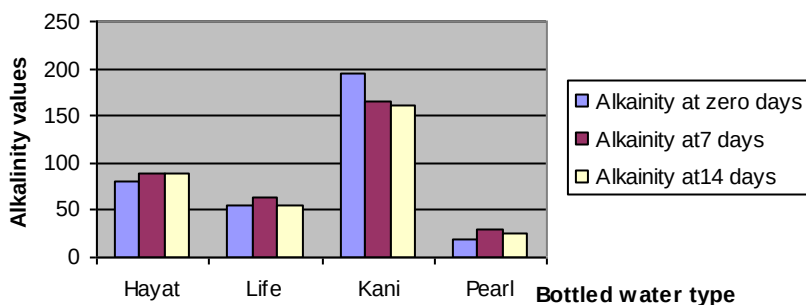
Table (3) International standard related bottled water quality

Parameters	Unite	WHO(2006) drinking water	IBWA() Bottled water
pH	=	6.5 - 9.5	6.5_8.5
EC	$\mu\text{S}/\text{cm}$	1000	1000
TDS	mg L^{-1}	500	500
Alkalinity	MgCaCO_3/L	200	200
Hardness	mgCaCO_3/L	200	200
Ca+2	mg L^{-1}	100	100
Mg+2	mg L^{-1}	30	30
Na+	mg L^{-1}	20	20
K+	mg L^{-1}	10	10
NO3	mg L^{-1}	50	44

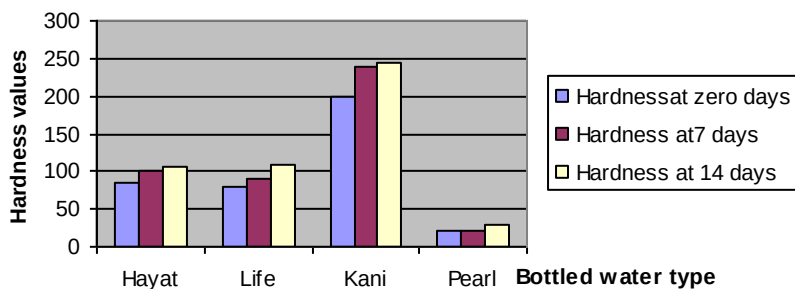




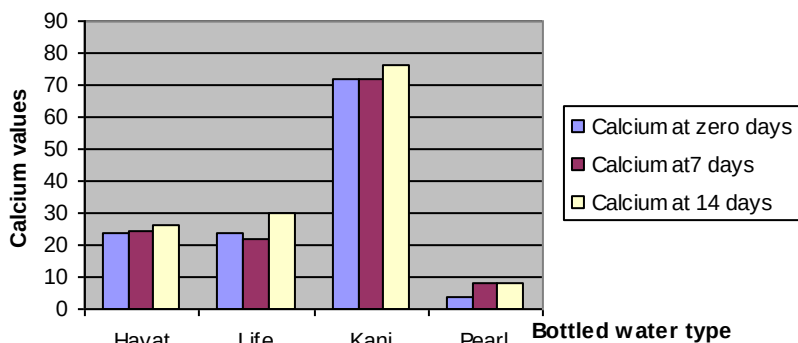
Figure(3):-Total dissolved solids recorded in different bottled water that exposure to sun light



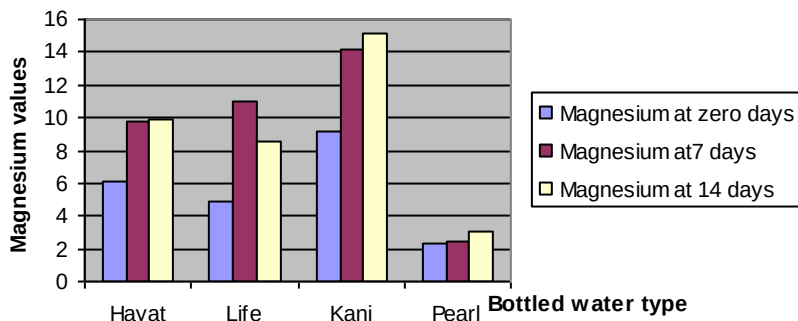
Figure(4):-Alkalinity values recorded in different bottled water that exposure to sun light



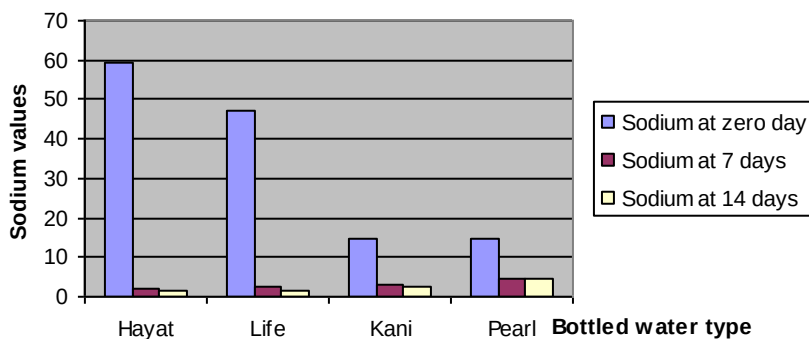
Figure(5):-Hardness values recorded in different bottled water that exposure to sun light



Figure(6):-Calcium values recorded in different bottled water that exposure to sun light



Figure(7):-Magnesium values recorded in different bottled water that exposure to sun light



Figure(8):-Sodium values recorded in different bottled water that exposure to sun light

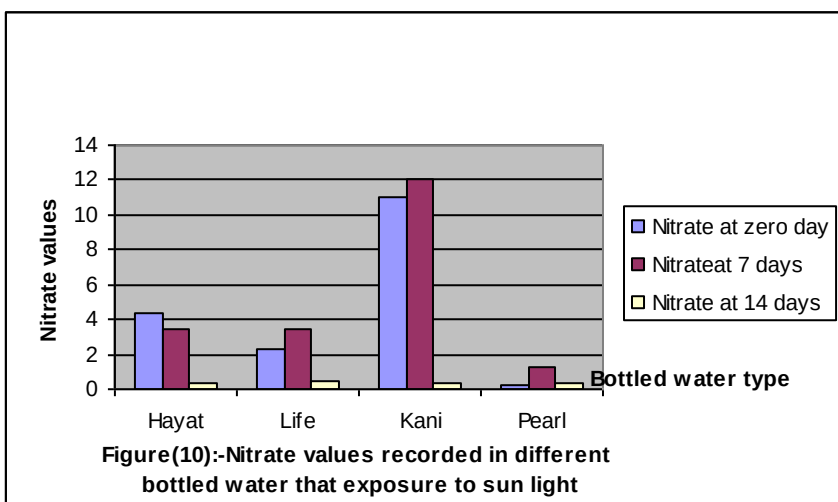
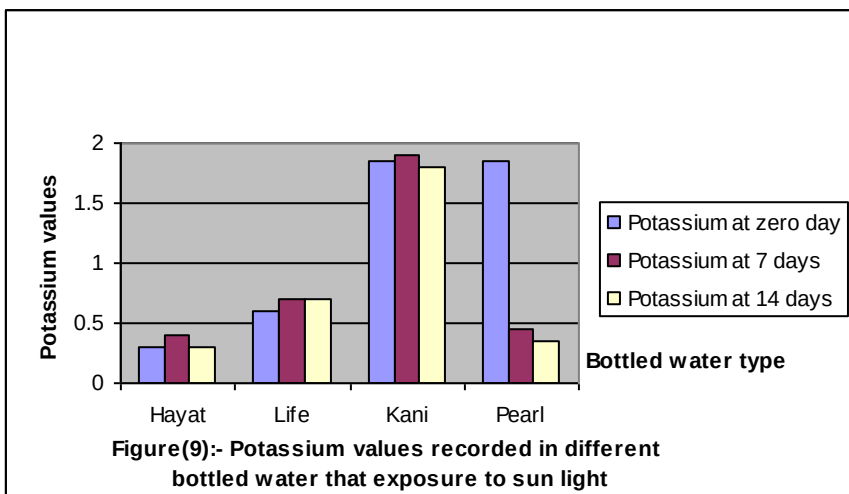


Table (4) Effect of temperature on Hayat bottled water after 7 days

Exposed to temperature	pH	EC	TDS	Alkalinity	Hardness	Ca+2	Mg+2	Na+	K+	NO3
0°C	7.77	133.0	85.12	95	85	24.05	6.07	59.50	0.3	4.35
25°C	7.58	135	88.88	86	95	26.05	7.29	0.1	0.2	0.6
35°C	7.57	185	118.4	85	115	32.86	8.02	0.2	0.4	0.0
45°C	7.57	190	123.6	80	165	32.06	20.65	0.1	0.2	0.0

Table (5) Effect of temperature on Life bottled water after 7 days

Exposed to temperature	pH	EC	TDS	Alkalinity	Hardness	Ca+2	Mg+2	Na+	K+	NO3
Control	6.36	160.5	102.72	55	80	24.05	4.86	47.15	0.6	2.25
25°C	6.40	159	101.76	50	85	26.05	4.86	0.3	0.4	0
35°C	6.56	171	104.44	50	135	28.85	15.31	0.3	0.4	0
45°C	6.45	172	106.04	50	155	32.06	16.07	0.3	0.4	0

Table (6) Effect of temperature on Kani bottled water after 7 days

Exposed to temperature	pH	EC	TDS	Alkalinity	Hardness	Ca+2	Mg+2	Na+	K+	NO3
Control	7.12	366	234.2	200	220	72.14	9.72	14.95	1.85	11
25°C	7.10	365	233.6	189	240	72.14	14.58	2.50	1.85	8.75
35°C	7.17	400	256.0	192	245	94.18	16.21	2.50	1.9	8.1
45°C	7.10	403	258.48	178	250	96.18	16.48	2.70	1.9	9.15

Table (7) Effect of temperature on Pearl bottled water after 7 days

Exposed to temperature	pH	EC	TDS	Alkalinity	Hardness	Ca+2	Mg+2	Na+	K+	NO3
Control	6.64	32	6.48	20	20	4.01	2.43	14.95	1.85	0.25
25°C	6.53	32	16.48	25	32	5.02	4.07	4.2	0.2	0
35°C	6.44	36	18.64	35	50	8.01	7.29	4.2	0.2	0
45°C	6.32	38	19.44	30	75	12.02	14.58	4.5	0.1	0

Table (8) Effect of temperature on Hayat bottled water after 14 days

Exposed to temperature	pH	EC	TDS	Alkalinity	Hardness	Ca+2	Mg+2	Na+	K+	NO3
Control	7.50	133.0	85.12	80	85	24.05	6.07	59.50	0.3	4.35
25°C	7.59	157.0	100.48	180	140	28.06	6.58	0.3	0.2	1.25
35°C	7.52	169.5	108.48	175	112.5	33.12	7.89	0.3	0.2	1
45°C	7.52	177.0	115.08	167.5	125	34.06	9.075	0.3	0.2	0.7

Table (9) Effect of temperature on Life bottled water after 14 days

Exposed to temperature	pH	EC	TDS	Alkalinity	Hardness	Ca+2	Mg+2	Na+	K+	NO3
Control	6.62	160.5	102.72	55	80	24.05	4.86	47.15	0.6	2.25
25°C	6.50	182.0	116.48	86	90	25.05	19.44	0.4	0.4	0
35°C	6.63	215.0	123.76	108	112.5	34.24	6.68	0.4	0.4	0
45°C	6.60	231.5	129.76	100	120	35.43	19.44	0.4	0.4	0

Table (10) Effect of temperature on Kani bottled water after 14 days

Exposed to temperature	pH	EC	TDS	Alkalinity	Hardness	Ca+2	Mg+2	Na+	K+	NO3
Control	7.12	366.0	234.2	135	220	72.14	9.72	14.95	1.85	11
25°C	7.18	380.5	175.52	455	300	82.13	23.09	2.6	1.85	9.45
35°C	7.34	472.0	280.08	440	280	80.16	19.84	2.65	1.9	8.57
45°C	7.32	477.0	292.88	450	290	86.17	13.36	3.3	0	6.05

Table (11) Effect of temperature on Pearl bottled water after 14 days

Exposed to temperature	pH	EC	TDS	Alkalinity	Hardness	Ca+2	Mg+2	Na+	K+	NO3
Control	6.64	32	20.48	20	20	4.01	2.43	14.95	1.85	0.25
25°C	6.55	28	17.92	50	35	10.02	2.43	4.4	0.2	0
35°C	6.42	30.5	19.52	50	25	20.63	4.25	4.5	0.2	0
45°C	6.33	38	22.56	35	40	22.02	4.43	5.75	0	0

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