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Effect of storage temperature and sunlight exposure on the physicochemical properties of bottled water in Kurdistan region-Iraq

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ABSTRACT: Physicochemical properties (pH, Electrical conductivity, Total dissolved salt, Cl^{-} F^{-}, NO_3^{-}, SO_4^{-2}, NH_4^{+} and Chemical oxygen demand) of Sixteen brands bottled water in Kurdistan region-Iraq were analyzed using standard methods. The physicochemical properties of the bottled water measured in this work compared with manufacturer's labeling reported on the bottles and were compared with the guideline value of World Health Organization (WHO) and International Bottled Water Association (IBWA) standards. The change of physicochemical properties investigated when the bottled water exposed to sunlight or storage at different temperature for 30 days. IR-spectroscopy was carried out in order to deduce the nature of polymer material and its purity. Results indicated that the quality of bottled water samples was within the permissible limit, while it is changed with the time of sunlight exposed or temperature changes. The results indicate, the physicochemical properties of all bottled water samples are within the international guidelines of bottled water and not the same that reported on the bottle label. The results show each of sun light exposure and temperature of storing cause changes in all physicochemical properties of water in the plastic bottle. @JASEM

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 (Samadi MT. et al. 2009). Bottled water quality are subjected to intensive investigation in many countries worldwide, in order to evaluate its suitability for human consumption. The quality of water may vary from one source to another based on several parameters such as water sources, type of water purification, and storage tanks (Mufeed I. 2006).The quality and physicochemical properties of bottled water have been study extensively in many countries, for examples in Saudi Arabia (Maqbool Ahmad. Et al. 2009), Greek (Stavroula V. et al. 2008), Brazil (C. P. Jordao. et al. 2007), Iran (Samadi MT. et al. 2009), United Arab Emirates (Zeinelabidin . 2009), South Korean (Bong YS. et al. 2008), Kuwait (Al-Mudhaf HF.et al 2009), Jordan (Mufeed I. 2006) , Bahrain (Musaiger A. et al. 1990), Canada (Page, B. D.et al. 1993) and USA (Allen, H.et al 1989).

Polyethylene terephthalate (PET) is the material most commonly used to make the clear plastic bottles in which bottled water is sold. The contents of the PET bottle, and the temperature at which it is stored, both appear to influence the rate and magnitude of leaching of organic and inorganic compounds from pet bottle (Peter Schmida.et al 2008). Several studies have shown the presence of compounds in bottled water, in non negligible concentrations. Mutsuga M. et al (Mutsuga M.et al.2006) reported the acetaldehyde forming during the polymerization reaction and the hot step process in the bottle water manufacture. Farhoodi et al. (Farhoodi et al. 2008) studied the interaction of incubation time with storage temperature on the leaching of DEHP from PET bottles. Cristina Bach et al. (Cristina Bach et al.2009) tested water bottles after exposure to extreme conditions of high temperature and UV radiation to accelerate the possible migration of substances.

In sunlight exposure tests, Wegelin et al. (Wegelin et al. 2001) have shown that PET degradation products such as terephthalate monomers and dimers are primarily formed at the surface of the bottles. Peter Schmid et al. (Peter Schmid et al. 2008) sought to determine whether solar water disinfection (SODIS) would promote leaching of phthalates into water in PET bottles. SODIS is a technique used in developing countries to disinfect water by incubating water in PET bottles in direct sunlight. After 17 hr of incubation in direct sunlight, maximum concentrations of di(2-ethylhexyl)adipate and DEHP were 0.046 and 0.71 µg/L, respectively.From the literature on leaching of PET it becomes evident that time is a dominant factor governing the release of organic substances (Nawrocki, J.et al. 2002).

During the five years, there has been a considerable increase in the consumption of bottled water in Kurdistan region (north of Iraq), especially in the summer .According to the ministry of industry in 2010, 27 bottled water companies in Kurdistan region produced about 1.692 x 10^9 L of bottled water. Bottled water is also imported from Turkey country. The biggest bottled water production company in Kurdistan region is Life Company which produces 27 * 10^6 liter bottled water per year. The main source of bottled water sold in Kurdistan region is from springs, wells and surface water. Temperatures in Kurdistan region exceed 45°C at the summer time and the storing of bottled water in the car or out the

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of markets is a very common practice. Therefore, it is necessary to conduct the effect of temperature on the physicochemical properties of the bottled water. On the other hand, it is quite often for people to use the plastic bottled water outdoor and some markets leave it under sun light. Therefore, it is very important to understand whether nature sunlight may affect the quality of this bottled water.

This paper presents the results of a study aimed at evaluating the physicochemical water quality of locally produced bottled water in Kurdistan region. Comparisons of the results to standards as well as to the reported label values are presented. The effects of sunlight and temperature for 30 days on the quality on the Life bottled water have been carried out .the I.R spectra of the PET bottles were performed to deduce the nature and purity of the plastic, used as a packed bottled.

MATERIALS AND METHODS

Reagents and Solutions: Analytical reagent grade chemicals were employed for the preparation of all solutions. Freshly prepared deionized water was used in the experiments.

Bottled water sample: Sixteen brands of bottled water were collected from different supermarkets within three cities (Erbil, Sulaimanya and Duhok) in Kurdistan region. Each brand name and origin are given in Table 1.

Table 1: brand name, city of production and Physicochemical properties of bottled water samples

Name brands	Company / City	Cond. µs/cm	TDS mg L^{-1}	pH	COD mg L^{-1}	F^- mg L^{-1}	Cl^- mg L^{-1}	NO_3^- mg L^{-1}	SO_4^{-2} mg L^{-1}	NH_4^+ mg L^{-1}
Life	Ahram / Duhok	**342* (-)****	**171 (-)**	**7.8 (7.2)**	**6.634 (-)**	**0.173 (0.03)**	**8.610 (11.5)**	**3.316 (0.5)**	**19.41 (16.8)**	**N.D*** (-)**
Massafi	massafi / Erbil	**331 (-)**	**165 (120)**	**7.0 (7.5)**	**6.284 (-)**	**0.0834 (-)**	**5.093 (14)**	**4.388 (6.3)**	**15.397 (18.3)**	**N.D (-)**
Jin	Rawita/ Duhok	**339 (-)**	**170 (-)**	**7.8 (7.9)**	**7.472 (-)**	**0.192 (0.32)**	**7.194 (-)**	**3.164 (7.2)**	**18.602 (15.0)**	**N.D (-)**
Mazi	IMH/ Dohuk	**320 (-)**	**160 (-)**	**7.4 (7.3)**	**9.317 (-)**	**0.103 (-)**	**5.824 (1.4)**	**5.297 (1.1)**	**11.692 (4.2)**	**N.D (0.01)**
Tiyan	Tiyan/ Duhok	**348 (-)**	**174 (-)**	**7.9 (7.8)**	**6.723 (-)**	**0.049 (-)**	**8.397 (-)**	**2.753 (0.0)**	**17.764 (-)**	**N.D (0.0)**
Lolav	Ahram / Duhok	**345 (-)**	**173 (-)**	**7.7 (7.2)**	**9.591 (-)**	**0.121 (0.03)**	**5.360 (11.5)**	**5.725 (0.5)**	**19.710 (16.8)**	**N.D (-)**
Rovian	Rovian/ Duhok	**351 (10)**	**175 (124)**	**7.9 (7.2)**	**11.358 (9)**	**0.295 (-)**	**6.437 (-)**	**3.190 (-)**	**14.206 (-)**	**N.D (-)**
Hayat	Danon/ Kirkuk	**356 (-)**	**178 (-)**	**7.2 (7.5)**	**7.318 (-)**	**0.139 (-)**	**6.927 (4.1)**	**1.039 (-)**	**18,291 (2.74)**	**N.D (<0.05)**
Kani	Coca Cola/ Erbil	**318 (-)**	**159 (-)**	**7.6 (7.8)**	**9.824 (-)**	**0.206 (0.01)**	**8.837 (5)**	**5.814 (8)**	**21.43 (15)**	**N.D (-)**
Mira	BIUK/ Erbil	**324 (170)**	**161 (96)**	**7.8 (7.2)**	**7.492 (-)**	**0.062 (-)**	**5.532 (11)**	**6.247 (10)**	**18.603 (6.52)**	**N.D (0.0)**
Chiaa	Chiaa/ Karkuk	**361 (-)**	**180 (125)**	**7.4 (7.0)**	**8.764 (-)**	**0.010 (-)**	**6.614 (nil)**	**4.769 (-)**	**11.933 (-)**	**0.0012 (-)**
Rawan	Al Thuraya/ Erbil	**330 (-)**	**165 (50)**	**7.5 (7.7)**	**7.826 (-)**	**0.062 (-)**	**5.829 (10)**	**3.754 (6.5)**	**16.301 (-)**	**N.D (-)**
Sade Life	Karacadeg/ Istanbul - Turkya	**350 (376) µs/cm**	**188 (-)**	**7.8 (7.9)**	**6.519 (-)**	**0.199 (0.15)**	**8.492 (5.51)**	**0.952 (-)**	**12.293 (-)**	**N.D (<0.05)**
Ala	Ala/ Sulaimanya	**309 (-)**	**155 (-)**	**7.5 (7.3)**	**8.682 (-)**	**0.182 (-)**	**6.129 (4)**	**1.924 (-)**	**14.360 (12)**	**N.D (-)**
Shireen	Kamal/ Dohuk	**352 (-)**	**176 (118)**	**8.1 (7.3)**	**8.823 (-)**	**0.176 (< 0.1)**	**7.310 (6)**	**4.735 (0.1)**	**16.472 (10)**	**N.D (-)**
Alhayat	IMH/ Dohuk	**347 (-)**	**175 (-)**	**7.6 (7.3)**	**10.512 (-)**	**0.281 (-)**	**7.926 (1.4)**	**2.653 (1.1)**	**13.548 (4.2)**	**N.D (0.01)**

*values measured in this work: **values reported on label of bottled water: *** N.D: not detected

Analysis and Methods: Prior to analysis, all instruments were calibrated. pH was measured by using pH –meter (HANNA instrument model PHB) with combined electrode. EC was determined by conductivity meter Hi8314. IR Spectra were performed by IR 300 spectrometer from USA. Samples were prepared mechanically by cutting a part of the stretched PET bottle. The concentration of ions (Cl^- ٬ F^- , NO_3^- ,SO_4^{-2} and NH_4^+) in water was determined by Dionex ICS-1000 from USA connected with conductivity detector. The mobile phase for cationic measurement is 20 mM of methanelsulfonic acid and for anionic measurement are 3.5 mM Na_2CO_3 + 1.0 mM $NaHCO_3$. Bs-11, k109050.A calibration curve was prepared for each anion using aliquots anion concentrations higher than detection limits. The detection limits of F^-, Cl^-, NO_3^- and SO_4^{-2} were 0.05, 0.03, 0.13, and 0.03 mg L^{-1}, respectively. The calibration curves had a correlation coefficient =0.99 for each anion. Fig 1 shows anion chromatogram of Life bottled water sample. Determination of COD of samples was performed using standard method. The COD method involves open reflux reaction between the organic matter and the dichromate ion in a 50% sulfuric acid solution and titrated against the Mohr's salt. (Standard methods 1989).

The Life bottled water was taken as a sample for studies the effect of sunlight exposure and temperature storage. For the control experiments, bottled water was protected from light exposure by storing it in a dark place at room temperature (30^oC), each bottle was fully wrapped with aluminum foil. The effect of temperature on bottled water quality was monitored by adjusting the temperature of water bath between 25^oC to 65^oC. Experiments in the presence of sunlight were carried out, outdoor experiments during 5th of July to 5th of August from10am to 5pm, so that the irradiation was as intense as possible in Erbil city (capital of Kurdistan region, 360 km north of Bagdad). Incident solar radiation was measured within the wavelength of 285-2800 nm by Solar 118-Haenni radio meter. The mean sunlight intensity was recorded from 680 to 709 Wm^{-2} as shown in Table 2.

RESULT AND DISSECTION

Comparison studies of physicochemical properties: 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 (Lucy A. Semerjian 2010). As shown in Table 1, Most of water brands produced in Kurdistan region does not expose the necessary information. While many countries have national standard for bottled waters and some have national certification schemes, no accepted standard certification scheme yet exists in Kurdistan region or Iraq country for bottled water. In the present_work the results of physicochemical properties were compared with the guideline value of World Health Organization (WHO 2006) and International Bottled Water Association (IBWA 2008) standards (Table 3). Additionally the results of the physicochemical properties measured in this work compared with the reported label values for all bottled water samples (Table.1).

pH values: The pH values for all samples fluctuated between 7.0 to 8.1 .The pH values showed remarkable differences between pH determined and that reported on the labels (Table 1).The limit of pH value for drinking water according to IBWA is specified as 6.5 to 8.5. The pH shows slightly alkaline trend. Generally pH of water is influenced by geology of catchments area and buffering capacity of water.

Table 2: The Mean Intensity of sunlight and Temperature in Erbil city during 5th of July to 5th of August /2010 at the time interval 0 am to 5 pm

date	*The Mean Intensity (W/m^2)*	*The Mean Temp.*	
		Max.	***Min.***
5th -10th July	682	42	37
10th -15th July	689	41	37
15th -20th July	680	43	38
20th -25th July	694	45	39
25th -30th July	701	46	38
31st -4th Aug.	709	47	37

Electrical conductivity: The electrical conductivity results of bottled water samples showed short variation, which ranged from 309 to 361 µS/cm, (Table 1) all samples are within the IBWA limit for bottled water. Only one brand of water sample reported the EC value in its label.

Total Dissolved Solids (TDS): The TDS values of samples varied between 155 and 188 mg L^{-1} . These values were within the WHO and IBWA standards. As it is denoted in Table 1 there are remarkable differences between TDS values measured in this work with that of reported on the labels.

Chloride: The permissible limit of chloride in bottled water is 250 mg L^{-1}. The values of chloride determined in bottled water samples were very low (between 5.093 and 8.837 mg L^{-1}), within the permissible limit and different from that reported on the label.

Fluoride: Fluoride ions were found in all brands at concentrations between 0.010 and 0.281 mg.L^1. Fluoride in bottled water may come from natural sources. Fluoride exceeded all bottled water samples are within the international guidelines of bottled water and greater than that reported on the labels.

Ammonia: One bottled water brand contained ammonia at 0.0012 mg L^{-1} concentration. Ammonia enters water from fertilizer runoff, leaching septic tanks, and erosion of natural deposits.

Table 3: International standards related bottled water quality

Parameter	Unit	WHO(2006) Drinking water(GV)*	IBWA(2008) Bottled water(SOQ)**
PH	Units at 25°C	6.5 - 9.5	6.5 - 8.5
TDS	mg L^{-1}	1.000	500
Chloride	mg L^{-1}	250	250
Sulfate	mg L^{-1}	-	250
Nitrate	mg L^{-1}	50	44
Fluoride	mg L^{-1}	1.5	0.8- 2.4

* Guideline value; ** Standard of quality

Nitrates: Nitrate was found in all brands, at the concentrations between 0.952 to 6.247 mg L^{-1}. The nitrate concentration detected in all bottled samples are less than the minimum permissible limits (44 mg L^{-1}) .Determined concentration of Nitrate in all brand bottled water so greater than that reported on the bottles . Six brands of bottled water showed the concentrations of chloride ions greater than that recorded on the labels. While five brands not reported amount of nitrite on labels.

Sulphates: The sulphate levels varied between 11.360 and 21.43 mg L^{-1} 1. These concentrations were within the ranges of IBWA bottled water standards (250 mg L^{-1}). Sulphate exceeded all bottled water samples are greater than that reported on the labels.

Chemical Oxygen Demand: COD is used as a discharge standard parameter to deduce the amount of dissolved organic compounds in water (Baohui Jin et al. 2004). In the present work COD are measured to indicate the amount of dissolved organic compounds in bottled water under different condition. The observed COD values in all the bottled water samples are varying from 6.284 to 11.358 mg L^{-1}. The permissible limit of COD for drinking water is 255 mg L^{-1}. Hence the observed COD values in all the samples are well within the desirable limit. The COD values were reported only on one brand of bottles samples.

IR spectra of bottled: IR spectra of all brands plastic bottled were performed to characterize whether the plastic bottled made from PEF or other polyester. The characteristics bands of IR spectrum of bottled samples indicate that all plastic are made from PET the (Urban, M.W. 1996). Tables 4 shows the wave number and assignment of IR spectrum of plastic bottle of Life brand .As clearly seen in IR spectrum (Fig 2), all bands within the region 1000 to 1500 cm- , interacted and appear as a broad band .This may be due to chemical additives present in the PET bottled samples.

Table 4: Band assignments for IR spectrum of PET bottle of Life brand

Wave number (cm^{-1})	Assignment
3431	O-H stretching and bending of ethylene glycol end-groups
3054	Aromatic C-H stretching
2973, 2908	Aliphatic C-H stretching
1715	C=O stretching of aromatic ester
1614	C=C stretching vibration of aromatic ring
1578, 1505	Skeletal vibration of conjugation
872	C-H deformation of two adjacent coupled hydrogen on aromatic ring

Effect of sunlight exposed: The Measurement of physicochemical properties of sample has been carried out every five days for one month after exposing bottled water under natural sunlight. The results tabulated in Table 5 and Fig. 2 ,clearly indicate the increasing of the values of EC, TDS , COD , NO_3^- ,SO_4^{-2} and NH_4^+ with increasing of sunlight exposure time. While the values of pH, Cl^- and F^- were decreased with increasing of sunlight exposure time. The increasing of EC (from 342 to 360 µs/cm) and TDS (from 171 to 180 mg L-1) 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. (zeljka Fiket et al. 2007) ,(Helle Rusz et al. 2006). On the other hand, the increasing of EC and TDS were companied by increasing of ions concentration with sunlight exposure time. As clearly indicated by the results in Fig. 3, the sunlight radiation was lead to variation of COD amount of bottled water (increase from 342 to 460 mg L^{-1} during 30 days). Such variation can be attributed to the leaching of the compounds produced from the photodegradation of PET by sunlight

(Wegelin et al. 2001). Outdoor sunlight irradiation has been studied for its effects on organic compounds leaching. Schmid et al (Schmid et al. 2008) reported the leaching of 0.046 and 0.71 µg/L of di(2-ethylhexyl)adipate and di(2-ethylhexyl)adipate DEHP respectively ,after 17 hr of incubation in direct sunlight.

The data reveal that, over the 30-day exposures test, the concentration of NO_3^- , SO_4^{-2} and NH_4^+ increased from 3.316 to 3.741, 19.412 to 19.791 and N.D to 0.0129 mg L^{-1} respectively. These observations can be interpreted on the basis of the organic compounds in water (original organic compound in water and photodegradation byproduct leached from bottle) were converted to inorganic species (CO_2, NO_3^- , SO_4^{-2} and NH_4^+) by sunlight (Sulaiman Gafar 2010).

Table 5 Effect of sunlight on physicochemical properties of water samples

exposed to sunlight	Cond. µs/cm	TDS mg L^{-1}	pH	COD mg L^{-1}	F^- mg L^{-1}	Cl^- mg L^{-1}	NO_3^- mg L^{-1}	SO_4^{-2} mg L^{-1}	NH_4^+ mg L^{-1}
0	342	171	7.8	6.634	0.173	8.610	3.316	19.412	N.D
5	346	173	7.7	6.672	0.164	8.482	3.405	19.429	0.0092
10	346	173	7.5	6.693	0.155	8.390	3.468	19.593	0.0096
15	351	176	7.3	6.704	0.153	8.254	3.492	19.602	0.0103
20	354	177	7.3	6.753	0.142	8.202	3.564	19.690	0.0117
25	356	178	7.1	6.769	0.149	8.268	3.639	19.737	0.0125
30	360	180	7.0	6.797	0.157	8.433	3.741	19.791	0.0129

The decreasing of chloride ions (from 8.610 to 8.433 mg L^{-1}) and fluoride ions (from 0.173 to 0.157 mg L^{-1}) in bottled water sample can be suggested by occurring the chlorination and fluorination reaction during the sunlight exposure process. This suggestion is in agreement with the detection of toxic byproducts such as chloroform, bromodichloromethane, and haloacetic acids in bottled water by Beglen,T.H et al. (Beglen,T.H et al. 1989). The pH value of the bottled water was decreased from 7.8 to 7.0 when exposed to sunlight for 30 days. This can be ascribed to the oxidation of organic compounds through the photodegradation by sunlight which producing such compounds like phthalate ester (Monarca et al. 1994), haloacetic (Beglen,T.H et al. 1989)acids and acetaldehyde (Lo Russoet al. 1985).

Table6: effect of temperature on physicochemical properties of water samples.

Temperature	Time(days)	Cond. µs/cm	TDS mg L^{-1}	pH	COD mg L^{-1}	F^- mg L^{-1}	Cl^- mg L^{-1}	NO_3^- mg L^{-1}	SO_4^{-2} mg L^{-1}	NH_4^+ mg L^{-1}
25°C	0	341	170	7.7	6.627	0.170	8.623	2.884	19.602	N.D
	5	341	170	7.7	6.627	0.171	8.665	2.865	19.600	N.D
	10	342	170	7.8	6.627	0.173	8863	2.893	19.592	N.D
	15	343	171	7.7	6.628	0.171	8.578	2.858	19.632	N.D
	20	342	172	7.7	6.630	0.171	8.619	2.865	19.610	N.D
	25	343	172	7.7	6.631	0.170	8.593	2.870	19.629	N.D
	30	343	172	7.7	6.631	0.170	8.654	2.933	19.591	N.D
35°C	5	342	171	7.6	6.632	0.161	8.504	2.946	19.652	N.D
	10	343	172	7.6	6.643	0.157	8.415	2.959	19.682	N.D
	15	343	172	7.6	6.649	0.159	8.377	2.958	19.632	N.D
	20	344	172	7.6	6.655	0.161	8.249	2.972	19.711	N.D
	25	344	172	7.6	6.664	0.156	8.214	2.995	19.701	0.0015
	30	345	173	7.6	6.686	0.156	8.336	2.998	19.746	0.0017
45°C	5	343	172	7.6	6.669	0.150	8.317	3.107	19.838	0.0020
	10	345	173	7.5	6.680	0.145	8.252	3.115	19.841	0.0028
	15	345	173	7.5	6.693	0.137	8.100	3.126	19.901	0.0040
	20	347	174	7.5	6.706	0.120	7.925	3.129	19.969	0.0042
	25	349	175	7.5	6.714	0.121	7.908	3.144	20.018	0.0040
	30	351	176	7.4	6.748	0.119	7.831	3.169	20.143	0.0045
55°C	5	343	172	7.5	6.694	0.147	7.923	3.153	19.919	0.0052
	10	345	173	7.5	6.736	0.136	7.833	3.199	20.104	0.0061
	15	346	173	7.4	6.762	0.139	7.727	3.203	20.319	0.0090
	20	347	174	7.4	6.795	0.130	7.685	3.228	20.335	0.0102
	25	349	175	7.4	6.817	0.125	7.638	3.231	20.563	0.0180
	30	353	177	7.4	6.838	0.108	7.552	4.266	20.612	0.0267
65°C	5	344	173	7.4	6.739	0.136	7.785	3.327	20.036	0.0371
	10	346	175	7.4	6.826	0.129	7.628	3.395	20.377	0.0412
	15	350	177	7.3	6.863	0.121	7.452	3.414	20.521	0.0697
	20	352	179	7.3	6.988	0.113	7.404	3.428	20.531	0.0733
	25	357	182	7.3	7.003	0.098	7.360	3.447	20.579	0.0841
	30	361	184	7.3	7.091	0.081	7.200	3.483	20.692	0.0982

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 30 days to deduce the effect of temperature on the physicochemical properties values of bottled water. During 30 days of sample storage under 25^{o}C, no significant change of physicochemical properties was observed .While, when the temperature raised to 35^{o} 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^{o}, 55o and 65^{o}C as shown in Table 6. 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 (Lin, J. et at. 2000).

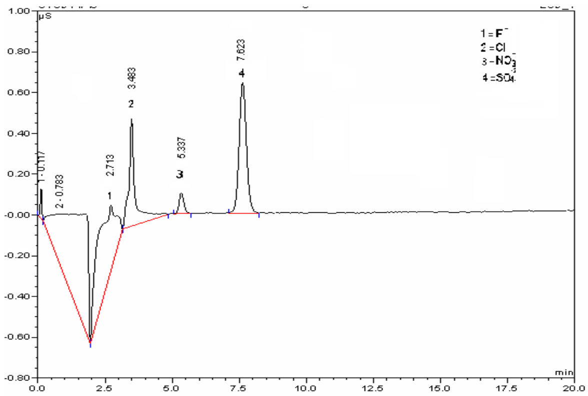

Fig. 1: Anion chromatogram of life bottled water sample.

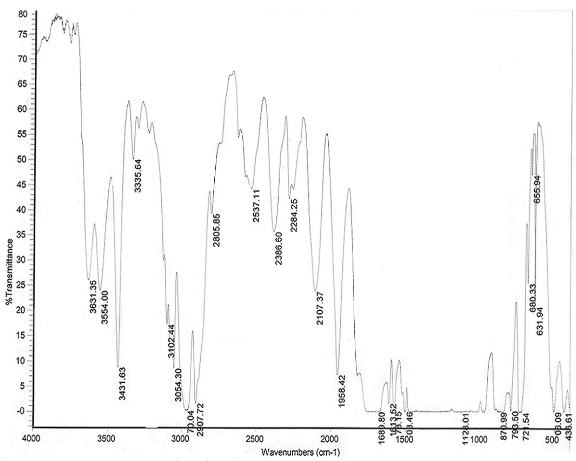

Fig .2: IR spectrum of Life plastic bottle.

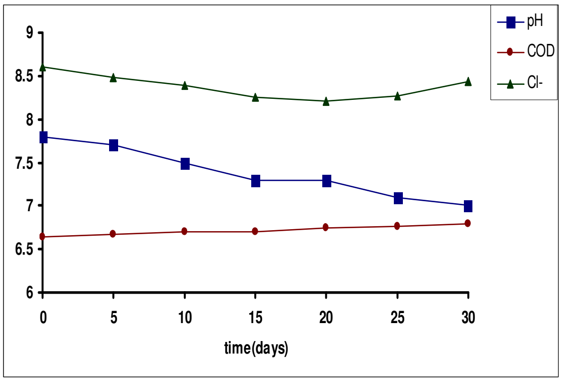

Fig. 3: Variation of pH, COD and Cl^{-} with the time of exposure to sunlight

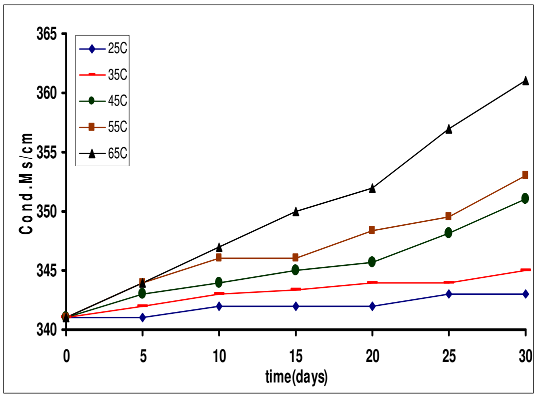

Fig .4: Variation of conductivity of bottle water sample with changing of temperature

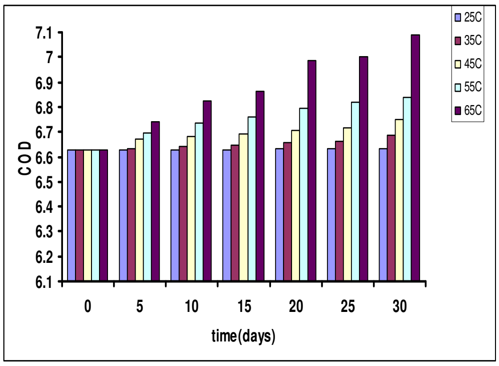

Fig .5: Variations of COD of bottle water sample with changing of temperature

It is reasonable to believe that the temperature may have similar effect as the sunlight exposing on the physicochemical properties change. Temperature above 35^{o} C leads to increasing the values of TDS NO_3^{-} , SO_4^{-2} and NH_4^{+} (due to formation from organic compounds degradation) and decreasing of chloride and fluoride ions (due to reaction of chloride and fluoride ions with the leached organic compounds).The result in Fig 4 show the conductivity increase with increasing temperature over a period of time, indicating the increase of ions.

The changes of COD values with temperature changing have been shown in Fig. 5.The results in this Fig. show no significant change of COD values during bottled water storage under 25°C .This means that thermal degradation did not occurs during the storage of bottled water under this temperature. While at the temperature above 25°C, the values of COD increased with increasing the temperature and the time of storage .These results suggest that high-temperature storage enhances organic and inorganic compounds leaching over a period of time. Temperature influences the leaching both of organic and of inorganic compound have been reported by Pinto B et al. (2009) and Franck Villain (1995).

Conclusion: 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.

2-Bottled water produced in Kurdistan region was characterized by low Cl^- and $NH4^+$ values compared to national and WHO guidelines for drinking water.

3-The information reported on the label dose not represent the real values of physicochemical properties.

4- Slight variations of physiochemical properties were found between the bottled water brands.

5- The storage of bottled water in condition above 35°C or exposure to sunlight leads to increasing the values of (Ec , TDS, COD, NO_3^-, SO_4^{-2}, NH_4^+) and decreasing the values of (pH, F^- and Cl^-) ,due to acceleration of organic and inorganic compounds leaching from bottled to the content water .

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