Quality of Bottled Potable Water Locally Consumed in Egypt

Mona, H.H. Bekhet
Food Science and Technology Dept., Fac. of Agric., Alex. Univ., 21545-El-Shatby, Alexandria, Egypt.

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ABSTRACT

Eleven commercial brands of bottled potable water locally consumed in Egypt, were investigated from the chemical and physicochemical points of view. Analysis included each of the following determinations : pH value, conductivity, total dissolved solids (TDS), total hardness (TH), total alkalinity(TAC), cations (calcium, magnesium, potassium, sodium, and iron), anions (bicarbonate, chlorides, fluorides, nitrate, phosphate, silica and sulphate) in addition to 14 heavy metals (antimony, arsenic, barium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver and tin).

Data revealed that all samples which were analyzed twice in two different periods cope in general with the standard specifications recommended by WHO and Environmental Protection Agency (USEPA). However, laboratory values for some chemical components were different from that mentioned on labels belonging to some brands.

Key words: bottled water, pH, conductivity, TDS, total hardness, total alkalinity, cations, anions, heavy metals.

INTRODUCTION

Bottled drinking water has become extremely popular with a current U.S. market of more than $ 11 billion. Its consumption has tripled in the past 10 years, making it the second largest beverage product category behind soft drinks. The U.S.A. consumption in the year 2006 was 32 billion liters of bottled drinking water as compared to 20 billion liters in the year 2001(IBWA, 2007).

Nowadays, an increasingly world wide concern about the quality of bottled drinking water has risen. It is worth to mention that quality attributes of such water can be evaluated by its concentration of organic and inorganic substances. It is obvious that mineral content of bottled water is one of the most important markers for water quality (Saleh *et al.*, 2001, Batarseh, 2006, Momani, 2006, Morr *et al.*, 2006, Raj, 2006, Soupioni, *et al.*, 2006, Saleh *et al.*, 2008)

It is well known that some minerals are required by our bodies for numerous biological and physiological processes that are necessary for health maintenance. In this respect, elements are classified into two main groups: The first includes elements that are required in our diet in amounts greater than 50 mg per day and designated as macro elements and the second group which includes elements required in amounts less than 50 mg per day and known as trace elements. Epidemiological studies have shown a strong correlation between several human diseases and the presence of trace elements in drinking water (Rivera *et al.*, 1981, Papaetropoulou *et al.*, 1997, Kerr *et al.*, 1999)

The present study was carried out to investigate the quality of bottled potable water locally consumed in Egypt and belonging to different commercial brands.

MATERIALS AND METHODS

Sampling

Two series of experiments were carried out with samples of eleven brands of bottled water distributed for consumption in Egypt. The samples were purchased from local markets in Egypt during September (2007) and January (2008). All brands of bottled water are sold in sealed plastic bottles. All bottles were kept sealed at 4ºC until the time of analysis.

Chemical and physicochemical analysis

All chemical methods were determined according to the methods described in the Standard

Methods for the Examination of Water and Wastewater (APHA, 2005). The pH value, conductivity and total dissolved solids (TDS) were measured using a pH meter model Hi9033 (HANNA instruments Italy). Total hardness, calcium , total alkalinity, chlorides and bicarbonate were determined by titration methods as follows: total hardness (TH) and calcium (Ca) were performed with titration by ethylenediaminetetraacetic acid (EDTA), total alkalinity (TAC) by using 0.02N sulfuric acid, chlorides by mercuric nitrate solution (0.041N) .All titrimetic methods used, were carried out by automatic titrator (Brand GMBH postfach 1155, Germany) . Silica, iron, sulfate, nitrate nitrogen ,fluoride and phosphate were measured by the colorimetric methods, described in APHA (2005). All spectrophotometric measurements were carried out using a DR/4000 spectrophotometer (HACH company Loveland, Colorado, U.S.A.). Sodium and potassium were measured by selective electrode by using platinum series combination (HACH Company Loveland Colorado, U.S.A.). Magnesium was estimated from the difference between hardness and calcium according to the standard method in APHA (2005). Antimony (Sb), arsenic (As), barium (Ba), boron (B), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), selenium (Se), silver (Ag) and tin (Sn) in samples were determined by inductively coupled plasma mass spectrometry (ICP-MS) Perkin Elemer ICP-MS Model DRC Π as described in the standard method No.3125 in APHA (2005).

Results obtained were subjected to statistical analysis using standard deviation (Steel & Torrie, 1980). All data were the average of two determinations.

RESULTS AND DISCUSSION

pH value

The data presented in Table (1) and Figure (1-a) indicate that the pH values ranged from 6.9 to 8.1 and from 6.8 to 8.2 for the eleven brands of bottled potable water investigated in the present study after the first and second periods, respectively. The pH values of all brands were within the acceptable limits (6.5–8.5) of the Egyptian, WHO (2008) and USEPA (1998a) standards. All bottle labels did not indicate the pH value. It is worth to mention that pH less than 6.5 or greater than 9.2 would markedly impair the potability of the water (WHO, 2006). In other words, pH lower than 4 will produce sour taste while higher value above 8.5 will give bitter taste. Meanwhile, pH below 6.5 starts corrosion in pipes and thereby release toxic metals such as Zn, Pb, Cr, Cu, etc. (Anonymous, 2003). The results of Saleh *et al.* (2001) indicated that the pH of five brands of Egyptian bottled water were slightly basic being approximately 8.0. Data presented here are in agreement with the data of Ammar (2003) who reported that four brands of Egyptian bottled water had pH values ranged from 6.7 to 7.4.

Conductivity and total dissolved solids

Table (1) and Figure (1-b) show that the conductivity of samples under study ranged from 230.0 to 706.0 and from 231.0 to 747.0 µs/cm for the first and second periods, respectively. The sample No. 7 contained the highest values (706 and 7470 µs/cm) followed by the sample No.9 which contained 598.0 and 590.0 µs/cm. Five brands in the 1st period and four brands in the 2nd period exceeded the WHO recommended values (400.0 µs/cm, Fig. 1-b).

Table 1: pH value, conductivity, total dissolved solids (TDS), total hardness (TH) and toatal alkalinity (TAC) of bottled potable water

Determination	1st Period		2nd period		Standard specification		
	Range	Mean±SD	Range	Mean±SD	WHO	USEPA	Codex
pH	6.9-8.1	7.5±0.4	6.8-8.2	7.6±0.4	6.5 - 8.5	6.5-8.5	6.5-8.5
Conductivity (µs/cm)	230.0-706.0	384.6±153.6	231.0-747.0	386.7±158.3	400		
TDS (ppm)	144.0-441.0	240.4±95.9	144.0-467.0	241.6±99.1	1000	500	
TH (ppm)	36.0-340.0	107.8±89.1	29.0-282.0	93.7±75.2			500
TAC (ppm)	12.0-286.0	114.6±72.7	11.0-259.0	102.0±65.4			

* Range of 11 brands of bottled water (two determinations for each)
(US EPA) Environmental protection agency, (WHO) World Health Organization.

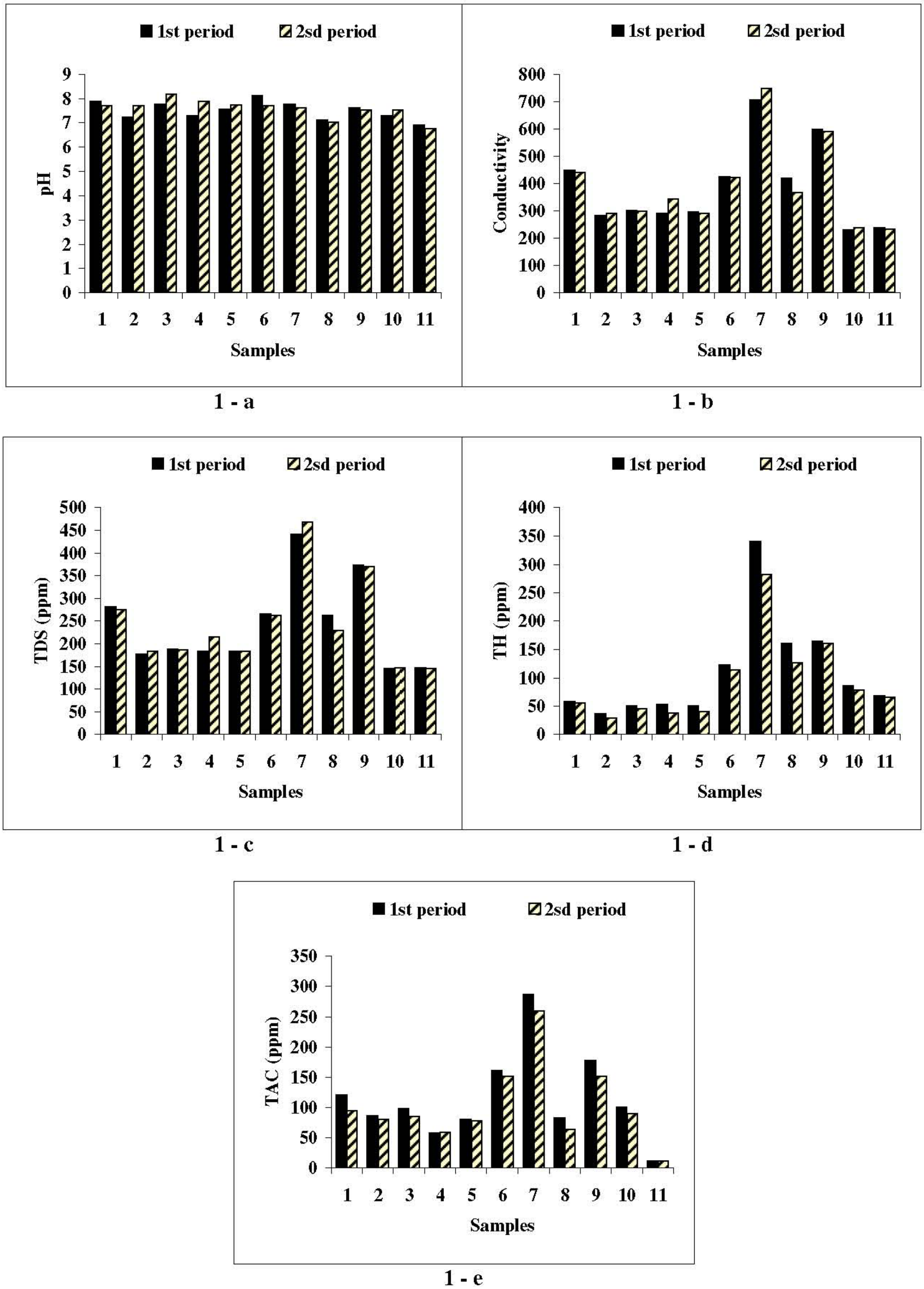

Fig.1: pH value, conductivity, total dissolved solids (TDS), total hardness (TH), and total alkalinity (TAC) of bottled potable water

Electric conductivity reflects total dissolved solids in drinking water. According to Saleh *et al.* (2001), conductivity values for five Egyptian bottled water were about 550.0 µs/cm.

Total dissolved solids (TDS) exhibited values ranged from 144.0 to 441.0 and from 144.0 to 467.0 ppm for the first and second periods, respectively being less than the value recommended in WHO (2003c) (1000.0ppm) and close to the USEPA recommended values (500ppm). From figure (1-c) it can be seen that samples No. 7 and No. 9 had the highest values of TDS(427.0–467.0 and 369.0–390.0), respectively. According to Ammar (2003), the TDS of four Egyptian bottled water ranged from 194.0 to 516.0 ppm. It is worth to mention that an elevated TDS concentration is not a health hazard. It was regulated by WHO (2003) guidelines because it is more of aesthetic rather than being harmful to health (Saleh *et al.*, 2008).

Total hardness

Total hardness (TH) of the samples under study ranged from 36.0 to 340.0 and from 29.0 to 282.0 ppm for the first and second periods, respectively as shown in Table (1). Also, sample No. 7 showed the highest value of TH (Fig. 1–d). All labels did not indicate the TH values. The point of interest is that the hardness levels above 500ppm are generally considered to be aesthetically unacceptable, although this level is tolerated in some communities (Zoeteman, 1980). The results of Ammar (2003) indicated that the TH ranged between 48.0 and 280.0 ppm for four Egyptian brands of bottled water. Calcium is one of the major elements responsible for water hardness. Water containing less than 60.0 ppm of Ca is considered as soft water. According to Saleh *et al.* (2008), there is no convincing evidence that water hardness causes adverse health effects in humans. In contrast, the results of number of epidemiological studies have suggested that water hardness may protect against disease (Derry *et al.*, 1990).

Total alkalinity

Table (1) and Figure (1-e) reveal that the total alkalinity (TAC) of water samples under study ranged between 12.0 and 286.0 for the first period of analysis, whereas it ranged between 11.0 and 259.0 ppm for the second period of analysis. The alkalinity of water is a measure of its capacity to neutralize acids. It is sum of all the titratable bases. It is mainly due to the presence of carbonates, bicarbonates, hydroxides, and it is less frequently due to, borates, silicates and phosphates or other bases if these are present (APHP, 2005). According to Ammar (2003), the alkalinity of four Egyptian water samples ranged from 30.0 to 124.0ppm. It was observed that sample No. 7 contained a higher value of TAC than the other samples (Fig. 1-e)

Mineral elements composition

Cations, anions, and trace elements were determined for the eleven brands of bottled potable waters under study. It was obvious that the concentrations of all dissolved major elements displayed large variation, which likely arose from the different geological origins of the water, including atmospheric and anthropogenic inputs, lithology, and ground water residence time, (Bong *et al.*, 2009).

a- Cation contents

Calcium concentration of the water samples ranged between 7.6 and 70.0ppm for the first analysis period, whereas it ranged from 4.0 to 74.0 ppm for the second analysis period (Table 2). The highest values (70.0–74.0 ppm) were observed in sample No. 7 (Fig. 2-a). Calcium concentration of bottled water is recommended by WHO (2006) to be 75.0ppm. Calcium is known to reduce cardiovascular disease, and high level of calcium make the water unpalatable (Gray, 1994). Moreover, Teixeria *et al.* (2001) reported the importance of Ca and Mg in the stabilization of various cellular structures. Meanwhile, it was reported that natural water sources typically contained concentrations of up to 100 ppm for calcium. However, levels of up to 800 ppm were found in natural water (Al-Redhimen& Abdel-Magid, 1985). Furthermore, Saleh *et al.* (2001) found that five brands of Egyptian bottled water had calcium levels ranged from 6.02 to 44.8 ppm. Ammer (2001), showed that calcium content of four brands of Egyptian bottled water ranged from 3.7 to 69.0. According to Chiba *et al.* (2006), calcium content in three commercial brands of Egyptian bottled water ranged from 46.18 to 66.28 ppm. Notwithstanding, Morr *et al.* (2006), reported that high calcium concentration is deleterious to the absorption and efficacy of biphosphonate group of drug in osteoporosis treatment. Water with high calcium concentration may also present an alternate pathway of calcium administration. In either case, knowing the actual concentration is critical. The average abundance of Ca in the soils is o.o7 to 1.7%; in streams it is about

Table 2: Cation contents (ppm) of the bottled potable water

Cations (ppm)	1st period		2nd period		Standard specification (ppm)		
	Range*	Mean ± SD	Range*	Mean ± SD	WHO	USEPA	Codex
Calcium	7.6-70.0	25.6±21.4	4.0-74.0	23.7±21.6	75		
Magnesium	4.13-40.00	10.63±10.34	2.40-23.50	8.35±6.19		50	150
Potasium	1.9-5.7	4.03±1.1	1.1-7.2	3.7±1.8	12		
Sodium	14.5-49.0	33.8±12.2	14.5-56.1	31.6±11.0	200		200
Iron	0.01-0.08	0.03±0.026	0.01-0.02	0.01±0.004	0.3	0.3	0.3

* Range of 11 brands of bottled water (two determinations for each)
(US EPA) Environmental protection agency, (WHO) World Health Organization.

15 mg/l; and in ground waters it is from 1 to >500 mg/l. The presence of Ca in water suppliers results from passage over deposits of limestone, dolomite, gypsum, and gypsiferous shale. Chemical softening treatment, reverse osmosis, electrodialysis or ion exchange is used to reduce Ca and the associated hardness (APHA, 2005).

Table (2) reveals that magnesium concentrations in water samples ranged from 4.13 to 40.0 and from 2.4 to 23.5ppm for the first and second analysis periods, respectively All samples were under the USEPA recommended level (50ppm). Sample No. 7 showed a higher level of magnesium being (23.50–40 .0ppm) than the other samples as seen in Fig (2-b). These results are in agreement with those reported by Saleh *et al.* (2001) and Chiba *et al.* (2006)

Potassium concentrations of water samples under study exhibited mean values of 4.03ppm ±1.1 and 3.7ppm ±1.8 for the first and second analysis periods, respectively (Table 2 and Figure 2-c). The values of potassium were indicated on all labels of the samples. Potassium level of bottled potable water is 12ppm as recommended by WHO (2006). According to other authors, the value of potassium ranged between 2.0 and 21.2ppm (Saleh *et al.*, 2001, Ammar 2003). Chiba *et al.* (2006) found that the mean of potassium concentration in bottled water was 5.51.

The data presented in Table (2) and Figure (2-d) show that the mean of sodium concentrations was 33.8 ppm ±12.2 and 31.6 ppm ±11.0 in the water samples at the first and second analysis periods, respectively. The values of sodium which reported on the labels of the bottles ranged from 13.0 to 102.0. Sodium content of the samples under study is within the acceptable limit of the Egyptian standard (150.0 ppm) and that (200 ppm) which recommended by WHO (2006). It is worth to mention that most water contains some sodium, which naturally leaches from rocks and solids. An excess of sodium more than 200.0ppm in drinking water may cause a salty taste, as well as health effects (Derry *et al.*, 1990). The aforementioned results agree with those reported by Ammar (2003) and Chiba *et al.* (2006).

The water samples under study possessed iron concentrations ranged from 0.01 to 0.08and from 0.01 to 0.02ppm for the first and second analysis periods, respectively (Table 2). All labels of the samples did not indicate the value of iron. The WHO (2003b) recommended iron levels in drinking water being 0.3 ppm. Accordingly, non of the samples investigated in the present study exceeded the allowable iron limits. Ammar (2003) noticed that iron content of the different brands of Egyptian bottled water, ranged from 0.29 to 0.42 ppm. But it can be seen from Fig. (2-e) that both samples of No. 4 and No. 7 had the highest values of iron in the first period of analysis, being 0.081 and 0.071 ppm, respectively.

b- Anion contents

Water samples under study exhibited bicarbonate concentrations ranged from 14.6 to 349.0 and from 14.6 to 315.9 ppm for the first and second analysis periods (Table3 and Figure 3-a). The labels of the samples showed that bicarbonate, ranged from 6.0 to 313.0ppm. Whereas chloride concentrations of the water samples under study ranged between 28.5 and 74.0ppm and from 12.6 to 77.6 for the first and second analysis periods, respectively. The WHO (2008)/USEPA (1998a) and Codex reported that the recommended concentrations of chlorides in bottled water is 250.0 ppm. Consequently, no

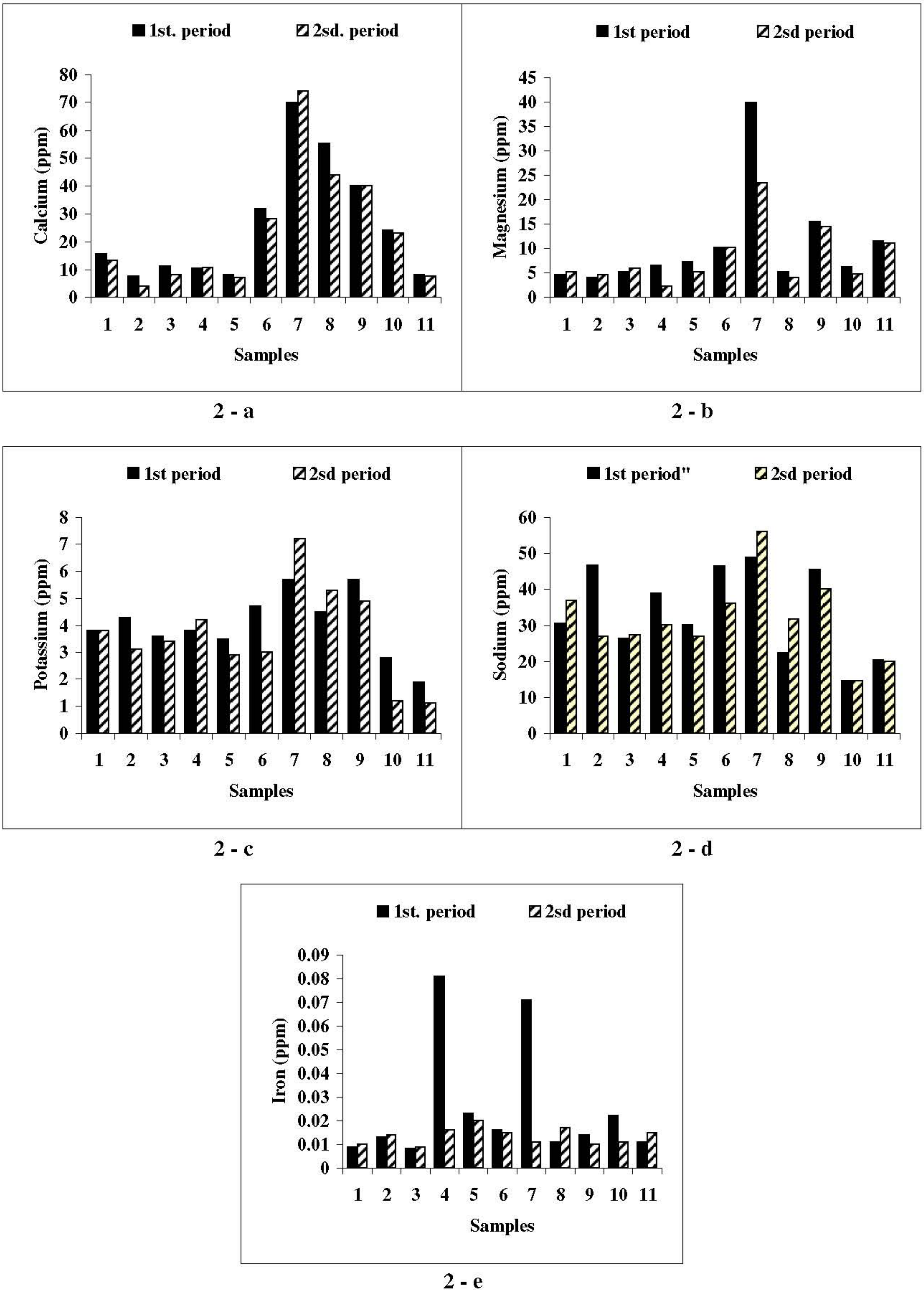

Fig.2: Cation contents of bottled potable water

brand examined here had chloride levels exceeded the standard guideline recommendations. No health – based guideline value was proposed by WHO (2003a), for chloride in drinking water. Chloride concentrations excess than 250 ppm can give rise to detectable taste in water, but the threshold depends on the associated cations (Zoeteman, 1980). Meanwhile, Saleh *et al.* (2001) reported that chloride content in 5 brands of Egyptian bottled water ranged from 11.06 to 53.80ppm except for one brand water which showed much higher level (221.0ppm). According to Ammar (2003), chloride contents in four brands of Egyptian bottled water, ranged from 28.0 to 90.0 ppm in all tested samples and these values are within acceptable limit of Egyptian and WHO (2003a) standards. Consumption of drinking water containing chlorides is not harmful to health (Saleh *et al.*, 2008).

Fluoride concentrations in water samples under study ranged from zero to 0.5and from zero to 1.7ppm for the first and second analysis periods, respectively (Table 3). Sample No. 6 showed the highest value of fluoride (1.70 ppm) in the second analysis period among the other samples (Fig. 3-c). The WHO (2006) and USEPA recommended values for fluoride is being 1.5, up to 4.0 ppm. Presence of large amount of fluorides is associated with dental and skeletal fluorosis (>1.5 ppm) and inadequate amounts with the dental caries (Anonymous, 2003). These results are in agreement with other studies (Saleh *et al.*, 2001, Güler, 2007), which reported that the fluoride concentrations ranged between 0.0 and 1.0ppm for bottled water.

The nitrate contents of the water samples under study ranged between 0.2 - 0.7 and between 0.1 –0.5ppm for the first and second analysis periods, respectively (Table 3). The bottled water of brands analyzed in the present study complies with the regulations currently in force for nitrate concentrations and they are suitable for use in the preparation of food for nursing infants. The WHO (2007), and USEPA (1998a) recommended 50.0ppm and 10ppm of nitrate concentrations in bottled water, respectively. All brands labels of the samples did not indicate the nitrate levels. Saleh *et al.* (2001) reported that non of the five Egyptian bottled water samples, that were analyzed showed any significant level of nitrate ion except one sample which had abnormally high level of nitrates, being about 19.0 ppm. Moreover, Ammar (2003) found that nitrate contents in four brands of Egyptian bottled water ranged from 0.002 to 0.19 ppm. High nitrate levels in drinking water can cause blue babies syndrome and certain forms of cancer (Khan & Chohan, 2009).

Phosphate concentrations of water samples investigated ranged from 0.01 to 0.17and from 0.01 to 0.31ppm for the first and second periods, respectively as shown in Table (3). Figure (3-e) shows that sample No. 7 had higher levels of phosphate (0.19-0.31ppm) than the other samples. Saleh *et al.* (2001) showed that low phosphate levels were detected in the Egyptian bottled water except for two brands which had levels of 2.1 ppm and 0.4 ppm.

The means of silica and sulphate concentrations of the water samples under study were 17.7 ppm ±11.2 and 24.2ppm ±12.5, respectively, for the first analysis period, while means were 18.36 ppm ±11.18 and 33.7 ppm ±12.9, respectively, for the second analysis period (Table 3 and Figures 3-f,

Table 3 : Anion contents (ppm) of bottled potable water

Anions (ppm)	1st. Period		2nd.period		Standard specification (ppm)			
	Range*	Mean ± SD	Range	Mean ± SD	WHO	USEPA	Egypt	codex
Bicarbonate	14.6-349.0	139.8±88.6	14.6-315.9	124.3±79.7				
Chlorides	28.5-74.0	45.2±18.6	12.6-77.6	44.1±25.7	250	250		250
Fluorides	0.0-0.5	0.35±0.2	0.0-1.70	0.47±0.44	1.5	4		1.5
Nitrate	0.2-0.7	0.3±0.2	0.1-0.50	0.23±0.10	50	10	50.0	10
Phosphate	0.01-0.17	0.08±0.04	0.01-0.31	0.10±0.08				
Silica	1.8-40.7	17.7±11.2	1.5-38.6	18.36±11.18				
Sulphate	11.7-54.9	24.2±12.5	12.6-55.0	33.7±12.90	500.0	250		

* Range of 11 brands of bottled water (two determinations for each)
(US EPA) Environmental protection agency, (WHO) World Health Organization.

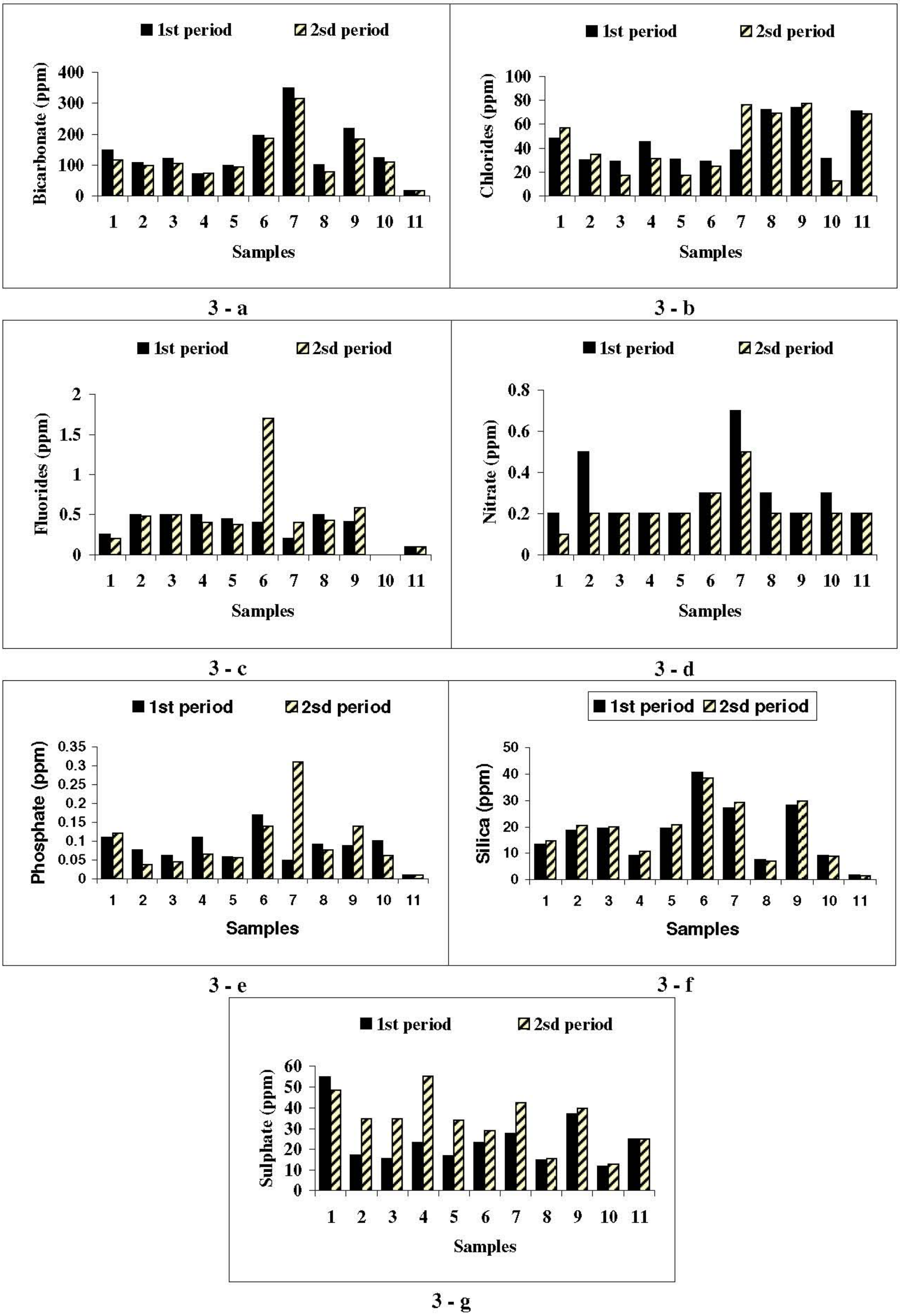

Fig. 3 : Anion contents of bottled potable water

3-g). Silicon is usually reported as silica when rocks, sediments, soils, and water are analyzed. Sulphate is one of the least toxic anions. The lethal dose for humans as potassium or zinc sulphate is 45g (Arthur, 1971). The WHO (2008) or USEPA (1998a) recommended concentration of sulphate being 500.0ppm and 250.0ppm, respectively. The results are consistent with data obtained by Saleh *et al.* (2001) who showed that all Egyptian water samples contained less than 80.0ppm of sulphate. No health –based guideline value for sulphate in drinking water is proposed by WHO (2006). Sulphate is widely distributed in nature and may be present in natural water in concentrations ranging from a few to several thousand mg/L (APHA, 2005)

Heavy metals

The bottled water samples were analyzed for 14 heavy metals; antimony, arsenic, barium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver and tin and the results are given in Table (4) and Fig. (4). It was obvious that non of the aforementioned heavy metals exceeded than the concentrations recommended by WHO (2008).

The results indicate that non of the bottled water samples investigated in the present study had antimony concentrations higher than the recommended value (5ppb) of WHO (2008) and USEPA (1984). Saleh *et al.* (2001) found that two brands of Egyptian bottled water contained higher levels of antimony (0.28 and 0.30). It is well known that most commercially available bottled waters are sold in polyethylene terephthalate (PET) containers. Antimony trioxide is used as a catalyst in the manufacture of PET, which typically contains several hundred milligrams per kilogram of antimony (Saleh *et al.*, 2008)

The results in Table (4) and Figure (4-b) showed that all samples under study contain arsenic, but the concentrations were below the recommended value (10ppb) of WHO (2008). The data presented here are not in agreement with that published by Saleh *et al.* (2001), who found that all samples of Egyptian bottled water analyzed were free from arsenic. A high concentration of arsenic in drinking water increases stillbirths and spontaneous an abortion, cause arsenism and black foot diseases, hyper pigmentation, cardiovascular diseases and skin cancer (WHO, 1981, US EPA, 1998a, Jain & Ali, 2000). Slotnick *et al.* (2006), reported that the reverse osmosis systems (RO) exhibited a reduction in arsenic content of water, by 85.5%.

Table 4 : Heavy metal contents (ppb) of bottled potable water

Metals (ppb)	1st Period		2nd period		Standard specification (ppb)			
	Range* (ppb)	Mean ± SD	Range* (ppb)	Mean ± SD	WHO	USEPA	Egypt	codex
Antimony	0.36-1.18	0.68±0.29	0.22-1.22	0.69±0.33	5	5	5	
Arsenic	0.16-1.03	0.44±0.25	0.20-1.22	0.49±0.29	10	10	10	50
Barium	4.82-293.44	84.64±110.88	3.15-290.12	83.23±109.45	700	2000	700	
Boron	11.71-199.50	58.22±54.02	12.25-200.15	59.00±54.09	500			
Cadmium	0.10-0.55	0.33±0.32	0.10-0.45	0.19±0.17	3	5	3	5
Chromium	0.10-3.11	0.82±1.08	0.10-3.19	0.78±1.08	50	100	50	50
Copper	0.13-2.79	0.49±0.77	0.12-2.5	0.45±0.68	2000	1300	1000	1000
Lead	0.10-0.12	0.11±0.01	0.10-0.15	0.13±0.04	10	10	10	50
Manganese	0.10-1.59	0.31±0.04	0.11-1.38	0.35±0.25	500		500	100
Mercury	<0.1		<0.1		1	1	1	1
Nickel	0.22-1.31	0.59±1.31	0.23-1.4	0.63±0.32	20		20	
Selenium	0.17-1.19	0.41±0.77	0.19-1.22	0.44±0.32	10	10	10	10
Silver	0.10-2.38	1.24±1.61	0.18-2.5	1.34±1.08	100	100		
Tin	0.10-0.15	0.13±0.03	0.10-0.1	0.1±0.00	0	1		

* Range of 11 brands of bottled water (two determinations for each)
(US EPA) Environmental protection agency, (WHO) World Health Organization.

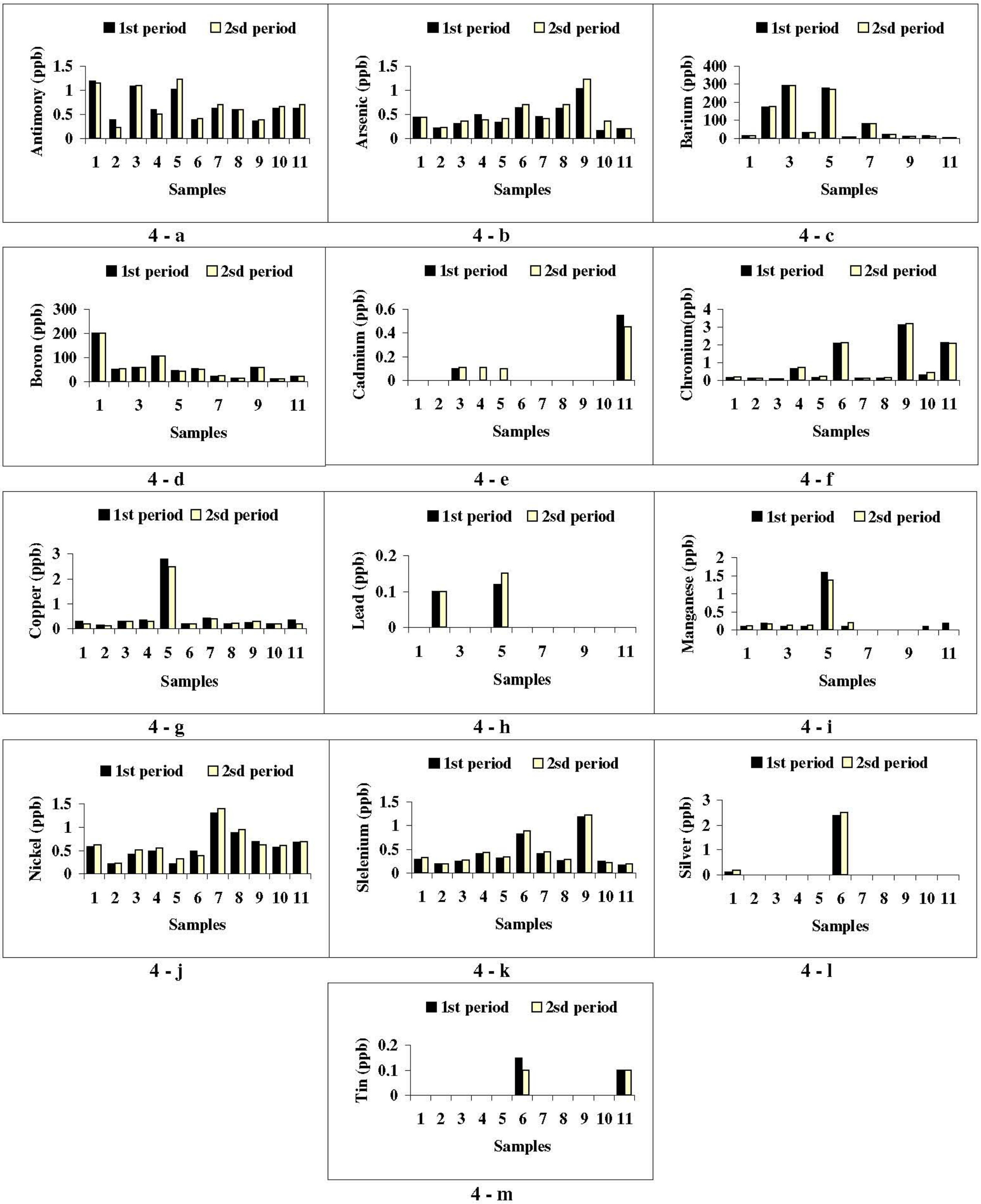

Fig. 4: Heavy metal contents of bottled potable water

The results given in (4) and Fig. (4) show that the barium concentrations in all samples in the present study were under the recommendation value (700ppb) by WHO (1990). Saleh *et al.* (2001), reported that two brands from five brands of Egyptian bottled water had much higher level of barium, one brand of them approached the maximum recommended value (700.0ppb) (WHO, 1990). At high concentrations, barium causes vasoconstriction by its direct stimulation of arterial muscle, peristalsis as a result of the violent stimulation of smooth muscle, and convulsions and paralysis following stimulation of the central nervous system (Stokinger, 1981). Chiba *et al.* (2006), showed that barium contents in 3 brands of Egyptian bottled water ranged from 34.0 to 93.0 ppb.

It was found that all the samples analyzed contained boron (Table 4 and Fig. 4-d) The recommended value by WHO (2008) for boron in drinking water is 500ppb. Both natural and anthropogenic factors can lead to the release of boron into air, water, or soil (Neal *et al.* 1998), resulting in boron contamination in ambient environment. Because of the wide application of borate and boric acid in industrial and other related fields, boron may also be discharged into the riverine environment with the drainage and leachate from mining industry (Akar, 2007). In boron industrial area, boron concentrations in surface water was about1.28 mg/L and in ground water was18.3 mg/L, which indicated that boron industry caused boron pollution in local water system (Xu *et al.* 2009).

Cadmium in 7 samples under study could not be detected, and in 4 samples ranged from 0.10 to 0.55 ppb (Table 4, Fig. 4e). These results agree with those reported by Saleh *et al.* (2001), and Chiba *et al.* (2006), who found that cadmium was below detection limit up to 0.02 ppb and 2.0 ppb, respectively. Cadmium ingestion above the drinking water action level can cause nausea, vomiting, salivation, sensory disturbances, liver injury, shock and renal failure in the short term, and in the long term, can cause kidney, liver, bone and blood damage (US EPA, 1998b). The WHO (2008) guideline value for cadmium in drinking water is 3 ppb.

All the samples of bottled water examined contained lower chromium concentrations than the current guideline value of 100ppb as recommended by USEPA (1987) (Table 4 and Fig. 4f). These results agree with those found by Saleh *et al.* (2001) and Chiba *et al.* (2006) for Egyptian bottled water.

The results presented in Table (4) indicate that non of samples analyzed contain levels of copper concentrations higher than the recommended maximum level of 2000.0 ppb (WHO, 2008). But, it was observed that sample No.5 contained the highest valued (2.50–2.79 ppb) among the samples (Fig. 4-g) The same trend was found by Saleh *et al.* (2001).

No lead was traced in all the samples under study exception of 2 samples contained 0.10 and 0.15 ppb (Table 4, Fig. 4-h). The standard specifications recommended maximum level of 10 ppb for lead (WHO, 2008, USEPA, 1998a and Egypt standards).

The results given in Table (4) indicate that manganese is found in 8 samples at low levels except sample No.5 which contained high level of manganese (1.38–1.59 ppb) (Fig. 4-i) but still at a level lower than that recommended by WHO (1996). These results are in agreement with those reported by Saleh *et al.*, (2001).

Mercury concentrations in all samples under study were below detection limit (< 0.1) (Table 4) and are in agreement with other studies (Saleh *et al.*, 2001). The guideline value for total mercury is 1 ppb (FAO/WHO, 1989). The potential health effects from drinking water with high mercury content may lead to kidney damage (US EPA, 1998a).

All samples analyzed in the present study had lower levels of nickel than the maximum suggested concentration of 20.0 ppb (WHO, 1996). It ranged between 0.22 and 1.4 ppb (Table 4 and Fig. 4-j).

The results in Table (4) show that all samples contained selenium and samples No.6 and No.9 showed the highest values (Fig. 4-k), but still lower than the recommended value (10ppb) of WHO (2008). While Saleh *et al.* (2001), found that selenium was below detection limits in five brands of Egyptian bottled water. These results agree with Chiba *et al.* (2006), who found that Se ranged from1.0 to 3.0ppb in three Egyptian bottled water. Ingestion of selenium above the action levels may cause hair or fingernail loss, numbness in fingers or toes and circulatory problems (US EPA, 1998a).

The results given in Table (4) indicate that the silver in all the samples under study was below detection limit except sample No. 6 which contained silver at a level of 2.50 ppb (Fig. 4i). Also, tin concentration was below detection limit (Table 4), excep two samples No. 6 and No. 11 (Fig.4m). Saleh *et al.* (2001) found the same trends for five brands of Egyptian bottled water. The recommended value by WHO (2008) is 100ppb for silver and zero for tin.

In conclusion, the commercial brands of bottled potable water locally consumed in Egypt cope in general with the standard specifications recommended by WHO and USEPA. However, analysis of some samples revealed different values from that mentioned on the labels of the samples. This diversity may be attributed to the variation of chemical composition due to geological and atmospheric conditions as stated by Bong *et al.* (2009).

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جودة مياه الشرب المعبأة والمستهلكة في مصر

منى حسن حسين بخيت

قسم علوم وتكنولوجيا الأغذية ،كلية الزراعة، جامعة الاسكندرية، الرقم البريدى ٢١٥٤٥، الشاطبى، الاسكندرية، ج. م.ع.

تم في هذه الدراسة تقدير الخواص الكيميائية والفيزوكيميائية لأحد عشر نوعاً من المياه المعبأة في مصر، وشمل التحليل تقدير كل من رقم الحموضة، التوصيل الكهربى، المواد الذائبة الكلية، العسر الكلى، القلوية، الكاتيونات (الكالسيوم، الماغنسيوم، البوتاسيوم، الصوديوم، الحديد) الأنيونات (البيكربونات، الكلوريد، الفلوريد، النترات، الفوسفات، السيليكا، الكبريتات) وأربعة عشر عنصراً من المعادن الثقيلة (الأنتيمون، الزرنيخ، الباريوم، البورون، الكادميوم، الكروميوم، النحاس، الرصاص، المنجنيز، الزئبق، النيكل، السيلنيوم، الفضة، القصدير) وتم سحب و تحليل العينات علي فترتين، ولقد وجد ان العينات مطابقة لمواصفات منظمة الصحة العالمية ماعدا التوصيل الكهربى لبعض العينات. ولوحظ ان معظم المعلومات الموجودة علي البطاقات الموجودة علي العبوات مختلفة عن التحليل اما بالزيادة أو النقص كما انه يوجد غياب لبعض المعلومات مما يستوجب تشديد الرقابة علي المعلومات المدونة علي البطاقة.