

## **DETERMINATION OF IONS (ANION AND CATION) BY ION CHROMATOGRAPHY IN DRINKING WATER FROM TALKHA TERRITORY AND SOME ITS VILLAGES, DAKAHLIA, EGYPT**

**Dawood, D.H. and M. I. Sanad**

**Agric. Chem. Dept. Fac. of Agric., Mans. Univ., Mansoura Egypt.**

### **ABSTRACT**

A simple, fast and sensitive ion chromatography (IC) method, for the determination of common ions (anion and cation) in water samples was developed. For comparison, selected samples of tap water, underground water, bottled mineral water and filtered tap water were collected and determined from Talkha and some villages, Dakahlia, Egypt. Ten ions of each anion and cation (fluoride, chloride, bromide, nitrate, sulphate, sodium, ammonium, magnesium, potassium, and calcium) were separated and analyzed, respectively. An isocratic elution with 4.5mmol/L Na<sub>2</sub>CO<sub>3</sub>, 1.0 mmol/L NaHCO<sub>3</sub> and 42 mmol/L methanesulfonic acid (MSA), IonPac AS22 and CS16 as the separation column and DS6 heated conductivity detector was used. The validation of the analytical method was studied in terms of linearity, sensitivity and accuracy. The linearity was between 0.9922 and 0.9992. And the detection limits ranged from 0.4µg/L to 72µg/L (S/N = 3) and satisfactory repeatability (RSD < 2.82%, n = 6). The recoveries were between 91.3% and 116.6%. All water samples were within the safety and acceptable levels of the World Health Organization (WHO, 2006) guidelines. Out of the samples of drinking water, only underground water had the slightly higher levels.

**Keywords:** Drinking water; Water analysis; Talkha; Egypt; Ion chromatography; Anions; Cations.

### **INTRODUCTION**

Water is the source of life on Earth for all living organisms, as Allah Almighty says in the Munificent Quran "And, We made from water every living thing" (The Prophets: 30). Air and water are the most important of all natural resources on the Earth. Water constitutes 75% of the human body weight and 80% of the total composition of most vegetables. At the same time, water causes an estimated 80% of diseases throughout the world. This is either due to water pollution, contamination or to water shortage. Safe drinking water is essential to humans, animals, plants and other life forms even though it provides no calories or organic nutrients. Over 1 billion people lack access to safe drinking water, and an estimated 80% of child deaths from digestive tract diseases such as diarrhea (approximately 2 million by the year) are caused by consumption of polluted and contaminated drinking water (Balbus and Lang, 2001 ).

Underground water is the major source of drinking water and also used as the alternative source for the agricultural and industrial sectors in the whole world (Mishra and Bhatt, 2008). In aquatic systems, elements are present as dissolved ions and complexes, suspended, colloids ions and solid in sediments. Concentrations of these ions strongly depend on biological processes, redox potential, ionic strength, pH, activities of organic and

inorganic chelators as well as scavenging processes (Arjonilla et al., 1994). Bottled mineral water has become a healthier choice than tap water for many people because they believe that bottled drinking water contains fewer contaminants. For this reason, the annual consumption of bottled drinking water in the world is substantial (Pip, 2000). Reverse osmosis (RO) process is used to obtain the filter water. It is one of the membrane-based desalination processes are a standard industry practice that has been refined in recent decades (Peñate and García-Rodríguez, 2012).

Many different methods have been reported in the literature for the analysis of ions (anion and cation) in water. Flame atomic absorption spectrophotometry has been traditionally used for cation determination either in water or in vegetable ashes (Aberoumand and Deokule, 2009). Concerning anions, many methods have been developed, which are in most cases specific for the separate analysis of every single anion. The A.O.A.C (2005) and the A.P.H.A (1998) defined individual methods, which have been traditionally used, for the determination of chloride, fluoride, nitrate, sulphate and phosphorus in water. Ion chromatography (IC) has become a powerful, widely used analytical method enabling simple, selective and fast determination of different varieties of inorganic anions and cations (Fritz and Gjerde, 2000).

The aim of the present study is to evaluate simple, fast and accurate method for the determination of ions included anions (fluoride, chloride, bromide, nitrate, and sulphate) and cations (sodium, ammonium, magnesium, potassium, and calcium) in different kinds of drinking water samples using ion chromatography (IC) equipped with a DS6 heated conductivity detector. Also, these selected drinking water samples of tap water, bottled mineral water (Baraka), filtered tap water and underground water were collected and estimated from Talkha and villages (Monshaat El-Badawi, Mit Al-Korama, Kafr Al-Khawazim), Dakahlia, Egypt.

## **MATERIALS AND METHODS**

### **Reagents and standards**

Milli-Q RG unit from Millipore (Thermo Scientific, Waltham, MA, USA) Deionized water was used for the preparation of solutions. Eluent solution was prepared by dissolving appropriate amounts of sodium carbonate ( $\text{Na}_2\text{CO}_3$ , Merck), sodium hydrogen carbonate ( $\text{NaHCO}_3$ , Merck) powders and methanesulfonic acid (MSA) ( $\text{CH}_3\text{SO}_3\text{H}$ , Aladdin, Shanghai, China) liquid, in Milli-Q water and degassing in an ultrasonic bath for 10 min. Standard solutions (1000 mg/L) of  $\text{F}^-$ ,  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{Na}^+$ ,  $\text{NH}_4^+$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^+$  and  $\text{Ca}^{2+}$  were prepared by dissolving approximately 100 mg salts in 100 mL deionized water. Working standards were prepared by further diluting. All solutions were stored in tightly closed containers at 4 °C.

### **Instrument and ion chromatographic conditions**

The separation of anions were performed on a Dionex (Thermo Scientific, Waltham, MA, USA) ICS-2000 ion chromatograph, equipped with a dual-piston pump, one valve (a six-port valve) and a 25  $\mu\text{L}$  sample loop. The

eluent flow rate was 1.0 mL/min. A DS6 heated conductivity detector was employed. An IonPac AG 22 (50 mm × 4 mm) guard column and IonPac AS22 (250 mm × 4 mm) analytical column were used for separation of anions. The eluent used for separation was comprised of 4.5mmol/L Na<sub>2</sub>CO<sub>3</sub> and 1.0mmol/L NaHCO<sub>3</sub> and the rinsing reagent for matrix elimination was deionized water. The separation of cations were performed on a Dionex (Thermo Scientific, Waltham, MA, USA) ICS-2100 ion chromatograph, equipped with a dual-piston pump, two valves (a six-port valve and a ten-port valve, we only use the six-port valve) and a 25 µL sample loop. An IonPac CG16 (50 mm × 5 mm) guard column and IonPac CS16 (250 mm × 5 mm) analytical column were used for separation of cations. The eluent used for separation comprised of 42 mmol/L methanesulfonic acid (MSA) and the rinsing reagent for matrix elimination was deionized water. All the instruments control and data acquisition were performed by Chromeleon 6.8 chromatography software (Thermo Scientific, Waltham, MA, USA). Under the working conditions all anions and cations were separated completely and total analysis time was 20 min. Anions and cations in samples were identified by the coincidence of their retention times with those of commercial standard anions and cations.

#### **Sample collection and preparation**

In this study, 16 samples of water (Tap water, Underground water, Bottled mineral water and Filtered tap water) were collected from four locations from Talkha (Talkha is a city on the Nile delta in northern Egypt in the Dakahlia Governorate). Placed on the west bank of the Damietta branch of the Nile, in the Delta region. Is about 120 km northeast of Cairo. Across from the city, on the opposite east bank of the Nile, is the town of Mansoura. Location I (Talkha city), Location II (Monshaat El-Badawi village), Location III (Mit Al-Korama village) and Location IV (Kafr Al-Khawazim village) all these villages belong to Talkha city. The tap water samples were collected in August 2013; from private house directly connected to the public water supply network. Underground samples were taken from (water pump) this water is available at the depth of 35m<sup>2</sup>. Bottled mineral waters (Baraka) were purchased from supermarket in August 2013; they were sold in polyethylene terephthalate (PET) bottles. Filtered tap water was obtained by filtration using the 6 stage reverse osmosis water filter system (RO) directly connected to the public tap water supply network. All samples were stored in tightly closed containers at 4 °C. Before injection, the samples were filtered through a 0.22 µm filter (Xiboshi, Tianjin Fuji Tech Co., Tianjin, China), and directly injected into the chromatographic system.

#### **Validation of the method**

##### **Linearity and sensitivity**

The external standard calibration method was used using the commercial standard solutions (1000 µg/L) and appropriate dilutions in pure water. Calibration curves of different anions and cations were prepared in six levels evenly distributed from: 0.025 to 2 mg/L for fluoride, 1.25 to 40 mg/L for chloride, 0.125 to 3 mg/L for bromide, 0.05 to 10 mg/L for nitrate and 0.5 to 40 mg/L for sulphate. On the other hand from: 5 to 60 mg/L of sodium, 0.01

to 0.5 mg/L for ammonium, 1 to 15 mg/L for magnesium, 1 to 8 mg/L for potassium and 2.5 to 40 mg/L for calcium. In order to check the sensitivity of the method under the working conditions used, the limits of detection (LOD) were studied. LODs were calculated as the concentration corresponding to three times the peak height of the baseline noise (signal-to-noise ratio of 3:1) (Ying *et al*, 2011).

#### **Accuracy**

The reliability and suitability of the IC method were studied, recovery experiments were carried out. Recovery percentage was obtained by measuring anions and cations contents in one water sample, before and after the addition of five different concentrations (1.5, 5.0, 1.5, 8.0 and 5.0 mg/L) of fluoride, chloride, bromide, nitrate and sulphate standard solutions, respectively and five different concentrations (8.0, 8.0, 1.0, 1.0 and 8.0 mg/L) of sodium, ammonium, magnesium, potassium and calcium standard solutions, respectively. Each test was repeated three times.

## **RESULTS AND DISCUSSION**

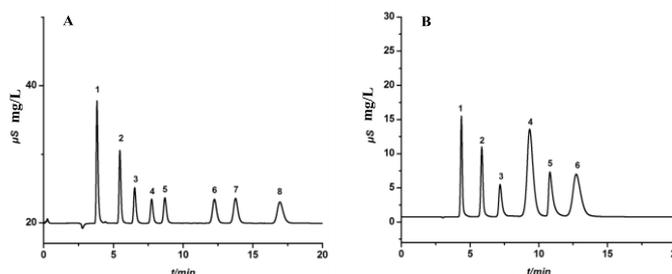
The most inorganic anions and cations are measured routinely in a wide variety of water samples such as tap water, underground water, and bottled mineral water. Therefore, a simple, suitably and fast method can determine all major anions and cations in natural water samples would be very useful for routine analysis (Wang *et al*, 2012). This study was aimed to determination of 5 inorganic anions (fluoride, chloride, bromide, nitrate, and sulphate) and 5 inorganic cations (sodium, ammonium, magnesium, potassium, and calcium) in drinking water samples from Talkha territory and some of its villages, Dakahlia, Egypt.

#### **The selection of chromatographic column and mobile phase (eluent)**

According to the literature (Cidu *et al*, 2011; Zhu *et al*, 2006), the IonPac AS22 and CS16 columns have a high capacity ion exchange could be efficiently separating anions and cations, respectively Fig. 1A and B. These efficient separations were achieved within 20 min. Fluoride, chloride, bromide, nitrate and sulphate Fig. 1A were good separated from their retention times. Also, from Fig. 1B it could be seen that lithium, sodium, ammonium, magnesium, potassium and calcium were simply identified from their retention times because they always have a good peak shape in less than 20 min.

The selection of an eluent is important to the success separation of anions and cations using ion chromatography (IC). A high eluent concentration should be used to obtain short analysis time (Wang *et al*, 2012). However, a low eluent concentration was necessary for a satisfactory resolution. To achieve a better separation of the weakly and strongly retained anions, 4.5mmol/L  $\text{Na}_2\text{CO}_3$  and 1.0mmol/L  $\text{NaHCO}_3$  was chosen as the eluent. By this eluent, all the 5 anions could be well separated and determined within 20 min in one injection and the flow rate was kept at 1.0 ml/min. At first, increasing methanesulfonic acid concentration decreased retention time of the cations. However, when its concentration was 42mmol/L,

all the cations (sodium, ammonium, magnesium, potassium, and calcium) could be well separated in less than 20 min with a single injection and the flow rate 1.0 ml/min. Thus, 42mmol/L was found to be suitable. The elution order was sodium, ammonium, potassium, magnesium and calcium.



**Fig. 1: The chromatogram of a standard solution. (A, Anions) Peaks (mg/L): 1=F<sup>-</sup> (10), 2=Cl<sup>-</sup> (10), 3=NO<sub>2</sub><sup>-</sup> (10), 4=Br<sup>-</sup> (10), 5=NO<sub>3</sub><sup>-</sup> (10), 6=PO<sub>4</sub><sup>3-</sup> (20), 7=SO<sub>4</sub><sup>2-</sup> (10), 8= I<sup>-</sup> (40). (B, Cations) Peaks (mg/L): 1=Li<sup>+</sup> (10), 2=Na<sup>+</sup> (10), 3=NH<sub>4</sub><sup>+</sup> (10), 4=Mg<sup>2+</sup> (10), 5=K<sup>+</sup> (10), 6=Ca<sup>2+</sup> (20).**

#### Validation of the method

##### Linearity and sensitivity

The linearity of the IC method was evaluated for the following anions: fluoride, chloride, bromide, nitrate and sulphate (Table 1) and cations: sodium, ammonium, magnesium, potassium and calcium (Table 2). The calibration curves showed a linear relationship between the peak area and concentration over a wide range of concentrations for all analytes (anions and cations). Calibration data of different anions (Table 1) and cations (Table 2), showed a good correlation ship between peak area and concentration, with a good correlation coefficient for all analytes under the IC working conditions used (Kapil et al, 2013).

The limit of detection (LOD) results showed that the high sensitivity of the IC method was obtained for all anions and cations with values between 0.4 and 72 µg/L (Table 1 and 2), the correlation coefficient and LODs results testified to the good linearity of this method.

**Table. 1: Calibration data of different Anions in standard solution by IC**

Analyte	Linear range (mg/L)	Correlation coefficient	LOD (µg/L)
F <sup>-</sup>	0.025 ~ 2	0.9971	10
Cl <sup>-</sup>	1.25 ~ 40	0.9940	24
Br <sup>-</sup>	0.125 ~ 3	0.9922	63
NO <sub>3</sub> <sup>-</sup>	0.05 ~ 10	0.9931	34
SO <sub>4</sub> <sup>2-</sup>	0.5 ~ 40	0.9992	72

**Table. 2: Calibration data of different Cations in standard solution by IC**

Analyte	Linear range (mg/L)	Correlation coefficient	LOD ( $\mu\text{g/L}$ )
$\text{Na}^+$	5 ~ 60	0.9982	1
$\text{NH}_4^+$	0.01 ~ 0.5	0.9950	0.4
$\text{Mg}^{2+}$	1 ~ 15	0.9948	2
$\text{K}^+$	1 ~ 8	0.9941	5
$\text{Ca}^{2+}$	2.5 ~ 40	0.9979	4

**Accuracy**

According Mehta (1997) requirements the selectivity of the proposed method is right because the peaks showed resolutions  $\geq 1.5$  for all the determined compounds. To confirm the accuracy of the method, ten replicate analysis of a standard solution were performed. The relative standard deviation (RSD%,  $n=6$ ) of peak area was below 2.82%, as shown in Table 3. Recovery values amounted to 91.3–116.6%. The closeness of the results to 100% confirmed the fairly good accuracy of the IC method.

**Table. 3: Recoveries and RSDs of detected Anions and cations.**

Analyte	Found (mg/L)	Added (mg/L)	Recovery (mg/L)	RSD ( $n=6$ ) %
$\text{F}^-$	2.196	1.5	94.3	1.66
$\text{Cl}^-$	9.754	5.0	102.9	1.40
$\text{Br}^-$	2.981	1.5	102.1	1.38
$\text{NO}_3^-$	14.50	8.0	96.3	1.54
$\text{SO}_4^{2-}$	10.29	5.0	99.1	1.39
$\text{Na}^+$	16.51	8.0	106.9	2.82
$\text{NH}_4^+$	7.301	8.0	91.3	1.10
$\text{Mg}^{2+}$	2.917	1.0	99.1	2.05
$\text{K}^+$	2.892	1.0	116.6	1.56
$\text{Ca}^{2+}$	14.97	8.0	92.4	1.79

**Sample determination**

This method was applied to the determination of anions and cations in drinking water samples from some villages in Talkha, Dakahlia, Egypt. The sample preparation was simple and comprised only filtration. For the filtered tap waters, the source water was treated with reverse osmosis technique. Subsequently, they were determined according to the specified chromatographic conditions. Analysis of the water samples for the anions and cations, were shown in Table 4 and 5 respectively.

Separation of all 5 anions was achieved within 20 min. It could be seen that 5 anions in the sample including fluoride, chloride, bromide, nitrate and sulphate could be detected in the water samples. The amounts of anions in the drinking water samples were listed in Table 4. It could be noticed from Table 4 that bromide was not detected in the water samples for the locations of Talka, Monshaat El-Badawi and Kafr Al-khawazim, respectively. Mit Al-Korama location, bromide anion was not detected only in the samples of Bottled mineral water and filtered tap water, while the sample of tap water recorded traces of bromide anion i.e 0.0001 mg/L. From the same table, it can be observed that bromide anion was detected in all underground water

samples with an amount of 1.52, 1.450, 1.701 and 1.490 mg/L for the locations of Talkha, Monshaat El-Badawi, Mit Al-korama and Kafer Al-khawazim, respectively. The highest level of bromide in underground water samples was recorded in Mit Al-korama (1.701 mg/L) while the lowest level in Monshaat El-Badawi (1.450 mg/L). The highest concentration of chloride could result in peak broadening and asymmetry for minor anions (Baeza – Baeza et al, 2010). Therefore, the underground water sample was diluted 10 times with deionized water before injection. From Table 4, it can be seen that the chloride and sulfate concentration in water samples were much higher than that of the other anions where chloride anion was represents the highest level (679.64 mg/L) in underground water of Kafr Al-Khawazim while the lowest level was 630.02 mg/L in underground water of Mit Al-Korama. The highest level of sulphate was 55.02 mg/L in underground water of Kafr Al-Khawazim, while the lowest value was 44.12 mg/L in underground water of Talkha.

**Table 4: The analytical results of water samples for Anions by IC**

Location	Analyte <sup>a</sup>	Type of water <sup>b</sup>			
		Tap water	nderground water	Bottled mineral water (Baraka)	Filtered tap water
Talkha (I)	F <sup>-</sup>	0.314	0.720	0.041	0.080
	Cl <sup>-</sup>	19.20	643.1	25.98	6.945
	Br <sup>-</sup>	nd	1.512	nd	nd
	NO <sub>3</sub> <sup>-</sup>	0.430	7.880	0.366	0.298
	SO <sub>4</sub> <sup>2-</sup>	30.18	44.12	19.06	3.992
Monshaat El-Badawi (II)	F <sup>-</sup>	0.291	0.753	0.049	0.069
	Cl <sup>-</sup>	21.33	677.5	26.14	6.013
	Br <sup>-</sup>	nd	1.450	nd	nd
	NO <sub>3</sub> <sup>-</sup>	0.479	8.252	0.372	0.308
	SO <sub>4</sub> <sup>2-</sup>	31.27	54.25	19.04	4.236
Mit Al Korama (III)	F <sup>-</sup>	0.324	0.760	0.045	0.078
	Cl <sup>-</sup>	22.02	630.02	25.12	7.021
	Br <sup>-</sup>	0.0001	1.701	nd	nd
	NO <sub>3</sub> <sup>-</sup>	0.422	8.112	0.310	0.299
	SO <sub>4</sub> <sup>2-</sup>	31.66	53.89	19.87	4.345
Kafr Al Khawazim (IV)	F <sup>-</sup>	0.333	0.840	0.042	0.084
	Cl <sup>-</sup>	21.65	679.64	25.01	6.812
	Br <sup>-</sup>	nd	1.490	nd	nd
	NO <sub>3</sub> <sup>-</sup>	0.499	8.340	0.392	0.314
	SO <sub>4</sub> <sup>2-</sup>	31.96	55.02	18.98	4.236

<sup>a</sup> Each represents the mean value of three determinations.

<sup>b</sup> Content (mg/L)

nd = not detected

Fluride content of underground water in Kafr Al-kawazim was represented the highest value i.e 0.840 mg/L, while the lowest value was detected in the bottled mineral water (Baraka) i.e 0.041 mg/L for Talkha location. Chloride content was ranged from 6.013 mg/L in filtered tap water for Monshaat El-Badawi to 679.64 mg/L for Kafr Al-Khawazim in underground water. Nitrate levels in the water samples were represented the lowest value 0.29 8mg/L in filtered tap water for Talkha location, while the location of Kafr

Al-Khawazim was represented the highest value i.e 8.34mg/L in underground water sample.

It could be seen that, the content of anions in filtered tap water was much lower than those in the other three types of water. In underground water, the concentrations of fluoride, chloride, bromide, nitrate and sulphate were represented the highest values especially in Kafr Al-Khawazim compared with the other three types of drinking water in different locations. Generally, the anions levels in all types of drinking water samples of Talkha location showed the best results compared with the other three locations.

Good separation of cations ( $\text{Na}^+$ ,  $\text{NH}_4^+$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^+$  and  $\text{Ca}^{2+}$ ) was obtained using 42 mmol/L methanesulfonic acid (MSA) eluent, within 20 min as a total run time (Fig. 1b). This eluent strength was found to give a better balance between suitable  $\text{Na}^+/\text{NH}_4^+$  (interfering ion) resolution and minimum peak broadening for  $\text{Mg}^{2+}$  and  $\text{Ca}^{2+}$ . From Fig. 1b the retention order of  $\text{Na}^+ < \text{NH}_4^+ < \text{Mg}^{2+} < \text{K}^+ < \text{Ca}^{2+}$ , the elution of magnesium before potassium was uncommon. When the concentration of the MSA was 42mM, this higher eluent concentration to a greater impact on the divalent magnesium ion. So that the magnesium was eluted before potassium. If the concentration of the eluent is less than 30mM, the possible retention order may be:  $\text{Na}^+ < \text{NH}_4^+ < \text{K}^+ < \text{Mg}^{2+} < \text{Ca}^{2+}$ , but such as divalent ion peaks are far less sharp peak than 42mM as obtained in this work is well justified. This is in line with the theory of the diffusion of analytes to the occluded pores and subsequent electrostatic repulsion proposed by Novic and Haddad (2006). The amounts of cations in investigated water samples are cited in Table 5.

**Table.5: The analytical results of water samples for Cations by IC**

Location	Analyte <sup>a</sup>	Type of water <sup>b</sup>			
		Tap water	Underground water	Bottled mineral water (Baraka)	Filtered tap water
Talka (I)	$\text{Na}^+$	25.01	490.11	33.85	7.230
	$\text{NH}_4^+$	0.201	0.012	0.049	nd
	$\text{Mg}^{2+}$	8.012	16.88	3.235	1.874
	$\text{K}^+$	3.445	5.960	2.321	1.812
	$\text{Ca}^{2+}$	28.25	22.01	9.452	7.662
Monshaat El-Badawi (II)	$\text{Na}^+$	24.82	578.23	34.42	7.959
	$\text{NH}_4^+$	0.168	0.101	0.057	0.0001
	$\text{Mg}^{2+}$	8.116	17.64	3.428	1.926
	$\text{K}^+$	3.566	5.867	2.168	1.736
	$\text{Ca}^{2+}$	28.71	22.33	9.685	7.587
Mit Al Korama (III)	$\text{Na}^+$	25.22	581.20	35.14	7.591
	$\text{NH}_4^+$	1.99	0.018	0.060	0.0001
	$\text{Mg}^{2+}$	8.332	16.98	3.812	1.871
	$\text{K}^+$	3.712	4.899	2.301	1.981
	$\text{Ca}^{2+}$	29.11	21.98	10.01	7.980
Kafr Al Khawazim (IV)	$\text{Na}^+$	24.18	588.11	34.69	7.569
	$\text{NH}_4^+$	0.178	0.100	0.063	0.0002
	$\text{Mg}^{2+}$	7.996	17.87	3.756	1.815
	$\text{K}^+$	2.885	6.021	2.693	19.41
	$\text{Ca}^{2+}$	29.02	22.85	10.12	7.680

<sup>a</sup> Each represents the mean value of three determinations.

<sup>b</sup> Content (mg/L)

nd = not detected

From Table 5 all samples of underground water showed in the four locations an increasing in the content of sodium cation, than other cations, where sodium cation was represents 588.11, 581.20, 578.23 and 490.11mg/L in the locations of Kafr Al-Kawazim, Mit Al-Korama, Monshaat El-Badawi and Talkha, respectively. Sodium cation in tap water samples was in the passable range, where it was represents 25.01, 24.82, 25.22 and 24.18mg/L in the locations of Talkha, Monshaat El-Badawi, Mit Al-Korama and Kafr Al-Kawazim, respectively. Sodium cation in the sample of bottled mineral water was aproximatly in equal level i.e 33.85, 34.42, 35.14 and 34.69mg/L for the previous location locations respectively. The lowest level of sodium content was observed in filtered tap water samples which ranged from 7.230 to 7.591mg/L. Ammonium cation in all samples water was ranged from (0.0001mg/L) in filtered tap water for both locations of Monshaat El-Badawi and Mit Al-Korama to (1.99mg/L) for the location of Mit Al-Korama in tap water. The highest value of magnesium and potassium were observed in the underground water samples of Kafr Al-Khawazim which were represent 17.87 and 6.021mg/L, respectively. These levels of magnesium and potassium cations are in the acceptable ranges. These results are in agreement with that obtained by (Audrius et al., 1998, Yongjian and Shifen, 2003).

Calcium cation content was high and approximately equal in all the first three samples except for filtered tap water, calcium content was low and approximately equal. Calcium content of tap water was ranged from (28.25mg/L) in Talkha location to (29.11mg/L) in Mit Al-Korama, while its content in underground water was (21.98mg/L) in Kafr Al-Khawazim. On the other hand, calcium content in bottled mineral water (Baraka) ranged from (9.452mg/L) in Talkha location to (10.12mg/L) in Kafr Al-Kahwazim location. Filtered tap water were distinguished with low content of calcium i.e (7.587mg/L) in Monshaat El-Badawi and (7.980mg/L) in Mit Al-Korama. From Table 5 it is quite clear that the cation contents were represent the highest values of  $\text{Na}^+$ ,  $\text{NH}_4^+$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^+$ , and  $\text{Ca}^{2+}$  in the water samples of underground water (588.11mg/L) in Kafr Al-Khawazim, tap water (1.99mg/L) in Mit Al-Korama, underground water (17.87mg/L) in Kafr Al-Khawazim, underground water (6.021mg/L) in Kafr Al-Khawazim and tap water (29.02mg/L) in kafr Al-Khawazim, respectively. The levels of  $\text{NH}_4^+$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^+$ , and  $\text{Ca}^{2+}$  in both tap water, underground water, bottled mineral water of the four locations are in agreement with the standard levels stated with (WHO, 2006), while sodium content was recorded high levels in underground water of the four locations.

Only a few ions such as fluoride and nitrate have been shown to cause widespread health problems in human as a consequence of exposure through drinking water when they are present in high quantities (WHO, 2006). In an attempt for evaluating the quality of the investigated water samples, compared with the WHO guidelines for drinking water (WHO, 2006) were compared. It can be seen that most samples agreed with guidelines exceptions include: underground water of Kafr Al-Khawazim have high levels from chloride and sodium 679.64 and 588.11 mg/L, respectively. Bromide did not detect in any of analyzed water samples except the underground water contained bromide in approximately 1.701 mg/L in Mit Al-Korama, which is

higher than the WHO guideline value. In spite of, the underground water sample has abnormally high levels of nitrate, about 8.340 mg/L in Kafr Al-Khawazim, but it is also lower than the WHO guideline value. The limit for nitrates in drinking water is 13.5 mg/L. This result was also in accordance with the report mentioned by Saleh et al (2001). Calcium is one of the major elements responsible for water hardness. Water containing less than 60 mg/L of  $\text{Ca}^{2+}$  is considered as soft water (Derry et al, 1990). Therefore, none of the analyzed water samples are considered as hard water.

In conclusion, an ion chromatography method using DS6 conductivity detector was successfully applied for the determination of ions (anion and cation) in drinking water samples. The above results show that this method is rapid, accurate, sensitive and suitable for the analysis of water samples. Some variations in amounts of anions and cations amounts between tap water, underground water, bottled mineral water and filtered tap water were detected, except for underground water which has slightly higher levels.

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تقدير الأيونات (أنيونات و كاتيونات) بواسطة التحليل الكروماتوجرافي الأيوني لمياه الشرب  
في مدينة طلخا وبعض القرى التابعة لها دقهلية - مصر  
داود حسني داود و مصطفى ابراهيم سند  
قسم الكيمياء الزراعية - كلية الزراعة - جامعة المنصورة - المنصورة - مصر

لقد تم استخدام طريقة التحليل الكروماتوجرافي الأيوني البسيطة والسهلة والأكثر حساسية لتقدير الأيونات (أنيونات و كاتيونات) الأكثر شيوعاً في عينات مياه الشرب في مدينة طلخا وبعض القرى التابعة لها. وقد تم اختيار عينات مياه الصنبور - مياه جوفية - مياه معدنية - مياه صنبور مفلترة (سبع مراحل). عشرة أيونات وكاتيونات (الفلوريد - الكلوريد - بروميد - نترات - كبريتات - صوديوم - أمونيوم - ماغنسيوم - بوتاسيوم - كالسيوم) تم فصلها وتقديرها. محاليل الإذابة في العمود الكروماتوجرافي المستخدم في حالة تقدير الأنيونات والكاتيونات ونوع العمود المستخدم بالإضافة الي نوع الكاشف المستخدم تم ذكرها في الطرق والمواد. وعن مدى إمكانية تطبيق هذه الطريقة تم دراسة من خلال (خطية الطريقة - الحساسية - الدقة). ومن خلال النتائج يتضح ان هذه الطريقة تتميز بالدقة والحساسية فالحدود الدنيا للتقدير كانت ما بين 0.4 ميكروجرام/لتر الي 72 ميكروجرام/لتر. كما اظهرت النتائج ان جميع عينات المياه تحت الدراسة مطابقة للمواصفات والمستويات المنصوص عليها في منظمة الصحة العالمية (WHO, 2006) الخاصة بمياه الشرب. ومع ان عينات المياه الجوفية أعطت مستويات أعلى قليلاً من الأنيونات والكاتيونات عن باقي العينات إلا انها أيضاً في الحدود المسموح بها.