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Drinking Water Quality: Chemical Evaluation of Tap Water And Bottled Water In Egypt.

KEYWORDS: Drinking water; Heavy metals; EC; pH; Cations; Atomic absorption.

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ABSTRACT *Drinking water is essential to life. It can be a source of exposure to pathogens, chemical, physical and radiological contaminants. The objective of the study is to gives information of major quality constituents of drinking water in Egypt. To achieve this goal, forty eight tap water samples were collected from sixteen different locations in some governorates in Egypt. In addition, nine selected samples from three common commercial bottled water were chemical analyzed. pH and EC were measured for water samples. Concentrations of some major cations (Na, K and Mg) and heavy metals in drinking waters such as:(Mn, Fe, Se , Zn Hg, Cd, and Pb) comparing with guidelines for drinking water organizations. Atomic absorption spectrophotometer was used for determination of elements in drinking water. The concentrations of heavy metals in tap water in Aswan were lower than the values observed in other regions of Egypt. Sodium content of bottled water was lower than the values reported on the labels of investigated samples of bottled water. Most samples were below the maximum guidelines set by World Health Organization.*

Introduction:

Water is a key to food security. Crops and livestock need water to grow. Agriculture requires large quantities of water for irrigation and of good quality for various production processes. Agriculture also confirmed its position as the biggest user of water on the globe. Safe and readily available water is important for public health, whether it is used for drinking, domestic use, food production or recreational purposes (WHO, 2015). Water quality requirements are a function of the type of food, processing conditions and methods of final preparation in the home (cooked/uncooked). Water of high quality is or will become a scarce commodity in many areas (Kirby *et al*., 2003). Egypt has been listed among the ten countries that are threatened by want of water by the year 2025 due to the rapidly increasing population. About 97% of Egypt's water resources are from the river Nile (Abdel-Shafy and Aly 2002). Most of Egyptian people are using tap water for drinking, cooking and daily used. In addition, public health, food industry, depends mainly on drinking water sources. The Nile is subject to unsustainably and shockingly high levels of industrial, agricultural and domestic wastewater pollution. However, few industrial waste-water treatment projects have been set up in Egypt. A powerful monitoring program is needed to provide reliable information about the current drinking water quality. Water contains macro elements such as sodium, calcium and magnesium which are necessary to sustain biological life and trace elements function chiefly as catalysts for enzymatic activity in human bodies. However, their accumulations cause acute or chronic poisoning and have to be removed from drinking water (Tayyeb *et al*., 2004; El-Harouny *et al*., 2008). Metals like Cu, Fe, Mn, Ni and Zn are essential as micronutrients for the life processes in animals and plants while many other metals such as Cd, Cr, Pb and Co have no known physiological activities (Kar *et al*., 2008; Suthar and Singh, 2008; Singh and Reza, 2010; Albaji *et al*., 2013).The increase of these heavy metals are much toxic and have tendency to accumulate in the body and may result in chronic damage. The natural concentration of metals in fresh water varies depend upon the metal concentration in the soil (Opydo, 1989).In addition, electrical conductivity affects the quality of water used for irrigation or drinking. Although pH usually has no direct impact on water consumers, it is one of the most important operational water-quality parameters. Careful attention to pH control is necessary at all stages of water treatment to ensure satisfactory water clarification and disinfection. For effective disinfection with chlorine, the pH should preferably be less than 8 (WHO, 1996).

Bottled water is a generic term that describes all water sold in containers. Many different types of water sources are used in the bottling industry (Gray, 2008). Several studies, which compared bottled and tap water concluded that, some bottled waters have better quality than tap waters but this is not always the case.

Lalumandier and Ayers 2000, Saleh *et al*., 2001; Doria , 2006). Chemical contaminants effect on acceptability of drinking water that would normally lead to reject of water. For that substance Health-based guideline values are needed to evaluate drinking water quality (WHO 2004 and 2008; USEPA, 2009; EU, 2014).

The present study aimed to envisage the water quality status of tap water and bottled water obtained from some governorates in Egypt. In addition, comparative study with WHO (World Health Organization), EU (European Union drinking water regulations statutory instruments) and USEPA (United States Environmental Protection Agency) were achieved.

Materials and methods:

The present experiment was conducted in the Central Laboratory, Faculty of Agriculture, Benha University during March to April, 2015.

Sampling:

Water samples were randomly collected from private residencies at different 16 locations in some Governorates in Egypt (S1:Cairo,S2:El Obour city, S3:Giza, S4: Alexandria, S5: Kafr El –Dawar, S6: Abu El-Matamir, S7:, S8: Faiyum, S9: Mansoura, S10 Shebin El Kom , S11: Abu Kebir, S12:Abu Hammad, S13:Minya, S14:Assuit, S15: Qena, S16: Aswan). Of each location, three water sampling were taken from different houses. Chemical studies were performed

Volume : 5 | Issue : 10 | October 2015 | ISSN - 2249-555X

for 48 household tap water samples. Tap water was kept in sealed glass bottles, refrigerated and transferred to the laboratory for analysis. Three different brands of the most popular commercial bottled water; S17, S18, S19 were purchased from local markets in Qalubia, Samples from three bottles of the 1.5 L size were analyzed for each brand. All brands of bottled water are sold in sealed plastic bottles and were kept in refrigerator until analysis. The determinations were performed within one week after sample collection.

Electrical conductivity (EC) and pH were measured using multi-parameter analyser Consort C830. The determination of metals in drinking water samples were performed with a Perkin Elmer 2380 Atomic Absorption Spectrophotometer. The wavelengths (nm) used for the determination of the analytes were as follows: Mg 285.2, Na 589, K 766.5, Cd. 228, Zn 213.9, Pb 283.3, Mn 279.5, Hg 253.7, Fe 248.3, Se 196. Five calibrated standard solutions of all monitored analytes were used.

Experimental design and statistical analysis:
Experiments were arranged in a completely randomized block design with 3 replications. Data were estimated as the mean and its standard deviation of the different traits. The calculations were done using Microsoft Excel 2010 program.

Results and discussions:
Data in table 1 show pH and electrical conductivity of tap water samples and bottled water in comparison with drinking water guidelines organizations. The pH values were in the range of 7.37-8.32 (lowest in Aswan, highest in Kafr El-Dawar). While bottled water have pH 7.2 and 7.3. WHO, 2008 reported that pH in drinking water should be 6.5-8.0. Moreover, EU, 2014 reported that pH in drinking water should be 6.5-9.5. (EC) which is a measure of water's ability to conduct an electric current is related to the amount of dissolved minerals in water, but it does not give an indication of which element is present. Higher value of EC is a good indicator of the presence of contaminants such as sodium, potassium, chloride or sulphate (Orebiyi *et al.*, 2010). Analysis of results found that all samples of drinking water had EC value less than EU, 2014 (Table 1). Tap water samples had EC values more than the limit of WHO 2008, while bottled water had less than the limit of WHO 2008. EC of tap water samples ranged from 209.1 µS/cm (Aswan) to 976.6 µS/cm (Abu Kebir). Bottled water had EC from 150 to 210 µs/cm.

Sodium salts (e.g., sodium chloride) are found in virtually all food (the main source of daily exposure) and drinking-water. Although concentrations of sodium in potable water are typically less than 20 mg/liter, they can greatly exceed this in some countries some water softeners can add significantly to the sodium content of drinking-water (WHO, 2008). In current study, sodium concentrations were in the range of 11.8-27.3 mg/1 (lowest in Aswan, highest in Assuit). The average level of sodium in tap water was 21.92 mg/l, higher than bottled water 14.1 mg/l (Table 1). No firm conclusions can be drawn concerning the possible association between sodium in drinking-water and the occurrence of hypertension. Therefore, no health- based guideline value set by WHO. Sodium content of bottled water was lower than the values reported on the labels of investigated samples of bottled water.

In this study, potassium content in Tap water was found to be higher than in bottled water (Table 1). Potassium does not cause intoxication because it is excreted by healthy kidney rapidly and also because large doses cause vomiting. However, after acute ingestion of potassium greater than 55 g for a 70 kg adult by individual with normal kidney function overwhelm homeostatic mechanism and caused death (Buckley *et al.,* 1995).

Manganese is an essential nutrient involved in the metabolism of amino acids, proteins, and lipids (Bouchard *et al.,* 2011). An inverse correlation between magnesium in drinking water and mortality from ischemic heart disease has been reported previously by Al-Saleh, and Al-Doush, 1998). Magnesium in the investigated water samples were found in the range of 11.9- 19.6 mg/L (Table 1). Magnesium level in bottled water was lower than in tap water. The concentration of tap water magnesium in present study is higher than the concentration of previous study reporter by El-Harouny *et al.,* 2008. The concentration of magnesium in bottled water in current investigation was lower than its concentration reported by the same study El-Harouny *et al.*, 2008.

Table 1: pH, EC and concentration of some major cations for drinking water in Egypt, and its comparison with WHO, EU and USEPA Guidelines for Drinking Water.

Location	pH	EC µs/cm	Na	K	Mg
S1	7.90	346.8	21.6±1.4	8.5±0. 9	14.7±0.7
S2	7.83	302.9	18.5±0. 7	7.8±1.2	12.4±1.4
S3	7.79	344.9	22.3±0.5	14.5±1.5	15.7±0.5
S4	7.64	490.1	23.6±0. 7	15.4±1.4	15.5±0.7
S5	8.32	500.1	22.9±0.9	25.9±1.1	17.0±2.1
S6	7.78	438.2	23.6±0.8	12.6±0. 9	14.0±0.8
S7	7.93	760.3	23.8±0. 3	13.9±0.7	6.5±0.7
S8	7.62	464.5	24.5±1.4	8.9±0. 3	16.8±0.9
S9	7.64	349.9	21.5±1.5	12.0±0. 9	16.3±.0.8
S10	7.48	500.8	21.5±0. 6	12.4±0.8	12.3±1.3
S11	7.59	976.6	22.2±0. 8	9.4±1.2	19.6±0.5
S12	8.12	713.6	23.6±0. 3	7.9±0.5	16.2±1.2
S13	7.80	273.6	15.9±0. 6	13.9±1.3	14.1±1.1
S14	7.62	626.0	27.3±0.8	8.3±0.7	17.1±2.0
S15	7.82	626.1	26.1±0.9	8.5±0.9	13.9±0.6
S16	7.37	209.1	11.8+0. 6	6.7±0.8	11.9±0.5
Bottled water					
S17	7.3	150.0	12.9±0.3	4.3±0.7	9.6±0.1
S18	7.2	223.0	15.9±0.4	3.9±0.2	8.2±0.3
S19	7.3	210.0	13.5±0.2	5.5±0.9	14.3±0.1
Drinking water guidelines					
WHO, 2008	6.5-8. 0	250	-	-	-
EU, 2014	6.5-9.5	2500	-	-	-
USEPA, 2009	-	-	-	-	-

Data were recorded in mean ± SD of 3 replicates. Na, K and Mg values were calculated in mg/ml for drinking water.

-: no guideline.

Results of trace heavy metal analysis in drinking water in Egypt regions are presented in Table 2. These results show that, Manganese level varies from 0.02 mg/L in Giza to 0.04 mg/L in Assuit. WHO, 2008 recommended limits for manganese is 0.4 mg/L and none of the drinking water samples analyzed show above that limit. The average manganese level of tap water was 0.26 which lower than the levels of manganese in bottled water 0.04. Al Otaibi and Zaki 2009 found that 68.75% of bottled water and 53.33%

Volume : 5 | Issue : 10 | October 2015 | ISSN - 2249-555X

of ground water exceeded the maximum permissible limit of manganese. Its concentration in tap water in Upper Egypt detected by Salem *et al.*, (2001), which was lesser than the result obtained in current study.

Iron is the fourth most abundant element by mass in the earth's crust. In water, it occurs mainly in ferrous or ferric state (Ghulman *et al.*, 2008). Iron may also be present in drinking-water as a result of the use of iron coagulants or the corrosion of steel and cast iron pipes during water distribution (WHO, 2008). Iron is an essential element in human nutrition. The highest iron level was found in El-Mahalla El-Kubra as 0.36 mg/L of tap water, while the lowest iron levels was found in Aswan as 0.03mg/L. About 81.25% of the samples comply the desirable concentration of iron in drinking water (0.3 mg/L) set by USEPA 2009. No guideline is set by WHO (2008) for iron content in drinking water because it is not of health concern at concentrations normally observed in drinking water. Results in table 2 were agreed with results obtained by other authors in other countries (Soylak, 2002; Mebrahtu and Zerabruk, 2011). Iron in bottled water samples were determined as 0.2, not detected and 0.05 mg/L. All iron levels in bottled water are within the accepted recommended levels by USEPA, 2009.

Selenium was also detected in two of the sampling areas in Asuit 0.03 mg/L and Alexandria 0.04 mg/L. It was detected also in bottled water 0.01 to 0.05 mg/L (Table 2). Detected samples were below the recommended levels of USEPA, 2009, above WHO, 2008 and EU, 2014 recommended levels.

Zinc is considered as an important trace element. In human bodies, it plays an important role in protein synthesis and is a metal which shows fairly low concentration in surface water due to its restricted mobility from the place of rock weathering or from the natural sources (Mebrahtu and Zerabruk, 2011). However, its accumulation in the human body causes tremors and it is also associated with nervous system causes depression (Gossel and Bricker, 1990). In this study, the lowest value was 0.07 mg/L in Giza and the highest value 0. 31mg/L in Abu Hammad was recorded. Although no guideline is set by WHO, 2008 and EU, 2014 for zinc level in drinking water. All samples analyzed were below the maximum admissible limit set by USEPA, 2009. Zinc concentration was, 0.05, 0.03 and not detected for the three samples of bottled water. However, zinc concentration in bottled water, was lower than its concentration in tap water (Table 2).

The major sources of mercury in drinking water are erosion of natural deposits; discharge from refineries and factories; runoff from landfills; and runoff from croplands (USEPA, 2009). In the present study, mean mercury level in tap water ranged from 0.91, 0.82 μg/L in cairo and Alexandria respectively to 0.15 μg/L in Aswan. These results were less than the results in the study of (Albaji *et al.*, 2013) .Mercury was detected in one sample in bottled water.

Cadmium concentrations in all samples analyzed were found to range from non-detectable to 1.11 μg/L, which significantly lower than the upper value (5.0 μg/L) set in accordance with legislation WHO, 2008, EU, 2014 and USEPA, 2009. Regarding the geographical distribution of cadmium concentrations, the highest values were determined in Cairo followed by Mansoura 1.10 μg/L. No Cadmium detected in Aswan. In bottled water Cadmium was not detectable. Cadmium is released to the environment in wastewater, and diffuse pollution is caused by contamination from fertilizers and local air pollution. Contamination in drinking-water may also be caused by impurities in the zinc of galvanized pipes and solders and some metal fittings (WHO, 2008). Cadmium is extremely toxic even in low concentrations. It will bio-accumulate in organisms and ecosystems, and it has along biological half–life in the human body. Long term exposures to Cadmium also induces renal damage .So cadmium is considered as one of the priority pollutants form monitoring in most countries and international organizations (Ehi-Eromosele and Okiei, 2012; Mohod and Dhote, 2013).

Table 2: Concentration of heavy metals in tap water and bottled water in some regions in Egypt and its comparison with WHO, EU and USEPA guidelines for drinking water.

Location	Mn	Fe	Se	Zn	Hg	Cd	Pb
S1	0.03±0.01	0.35±0.01	ND	0.17±0.14	0.91±0.14	1.11±0.07	0. 52±0.04
S2	0.03±0.21	0.20±0.02	ND	0.17±0.27	0.60±0.07	0.32±0.05	0. 32±0.01
S3	0.02±0.01	0.27±0.014	ND	0.07±0.01	0.6±0.27	0. 61±0.02	0. 55±0.07
S4	0.02±0. 09	0.24±0.01	0.04±0.01	0.18±0.01	0.82±0.20	0. 42±0.03	ND
S5	0.03±0.01	0.31±0.012	ND	0.19±0.20	0.71±0.06	0. 43±0.10	0. 43±0.12
S6	0.01±0.01	0.27±0.012	ND	0.13±0.14	0.33±0.14	0.52±0.01	ND
S7	0.02±0.09	0.36±0.03	ND	0.09±0.17	0.60±0.19	0. 31±0.03	0. 35±0.14
S8	0.03±0.03	0.30±0.07	ND	0.17±0.02	0.76±0.16	0. 54±0.08	0. 23±0.07
S9	0.03±0.04	0.24±0.03	ND	0.28±0.05	0.12±0.75	1.10±0.06	0. 36±0.14
S10	0.02±0.01	0.26±0.01	ND	0.11±0.12	0.63±0.28	0. 77±0.14	ND
S11	0.03±0. 05	0.14±0.25	ND	0.13±0.01	0.84±0.71	0. 21±0.07	0. 24±0. 08
S12	0.02±0.14	0.25±0.04	ND	0.31±0.14	0.61±0.17	0. 16±0.02	0. 23±0.09
S13	0.03±0.11	0.10±0.02	ND	0.25±0.14	0.72±0.28	0. 92±0.04	0. 38±0.06
S14	0.03±0.19	0.23±0.01	0.03±0.01	0.15±0.01	0.24±0.14	0. 22±0.03	ND
S15	0.02±0.52	0.15±0.03	ND	0.18±0.01	0. 82±0.06	0. 35±0.02	ND
S16	0.04±0.04	0.03±0.05	ND	0.17±0.14	0.15±0.01	ND	0. 12±0.04
Bottled water							
S17	0.01±0.10	0.2±0.001	ND	0.05±0.06	0.01±0.01	ND	0.11±0.02
S18	0.05±0.09	ND	ND	0.03±0.07	ND	ND	ND
S19	0.04±0.07	0.05±0.02	ND	ND	ND	ND	ND
Drinking water guidelines							
WHO, 2008	0.40	-	0.01	-	1	3	10
EU, 2014	0.05	0.2	0.01	-	1	-	10
USEPA, 2009	-	0.3	0.05	5	2	5	5

Data were recorded in mean ± SD of 3 replicates. Mn, Fe, Se and Zn values were calculated in mg/L drinking water while Hg, Cd and Pb were accounted inμg/L.

ND: non-detectable.
-: no guideline.

Lead is rarely present in tap water as a result of its dissolution from natural sources; rather, its presence is primarily from household plumbing systems containing lead in pipes, solder, fittings or the service connections to homes. The amount of lead dissolved from the plumbing system depends on several factors, including pH, temperature, water hardness and standing time of the water, with soft, acidic water being the most plumbosolvent (WHO, 2008). The levels of lead in the samples were in the range of 0.12-0.55 μg/L (minimum in Aswan, maximum in Giza). Lead concentrations in 31.25% of the samples were not detectable. The level for Pb recommended by the Environmental Protection Agency (USEPA, 2009) is 5 μg/L. The levels of lead in all samples were below this level. Led in bottled water was 0.11 for S17, the two samples S18, S19 were under the detection limit. Lead concentrations in bottled water were below the recommended levels of WHO, 2008, EU, 2014 and USEPA, 2009. In Saudi Arabia, Tayyeb *et al.*, 2004 and Al Nouri *et al.*, 2014, analyzed lead in drinking water and bottled water. It was within the maximum permissible WHO, 2008 level. In Egypt the results of the study of El-Harouny *et al.*, 2008 showed that the concentrations of lead in tap water and bottled water, it was also within the accepted recommended levels by WHO, 2008.

Conclusion:
The main goal of this paper was to assess the status of

Volume : 5 | Issue : 10 | October 2015 | ISSN - 2249-555X

drinking water quality in Egypt. The results show those values of pH, (EC), some cations, some heavy metals major cations Mg, K and Na and heavy metals in drinking waters such as Mn, Fe, Se, Zn, Hg Cd, and Pb comparing with guidelines for drinking water organizations. In Upper Egypt the contamination by heavy metals was low. Sodium content of bottled water was lower than the values reported on the labels of investigated samples of bottled water. Selenium in Alexandria sample was above maximum guidelines set by World Health Organization. On the other hand, all other samples were below the maximum guidelines set by World Health Organization.

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