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Study of some chemical elements contaminating drinking water from different sources

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Abstract

The current research included the evaluation of some elements, including Mg, Fe, Pb and Cd; in drinking water before and after their passing through water filters. High levels of most heavy elements are toxic to cells of the living organisms. The present target elements had been collected from five areas; three governorates: Cairo, Giza and Qalyubia beside Mostorod and Faculty of Education, where concentrations of their drinking water had been evaluated before and after passing through water filters. Finally, the results have been compared with recommendations of WHO. The results showed that Qualubia drinking water contains the highest concentrations of Mg, Pb and Cd while the Mostorod`s water showed the highest concentration of Fe before filtration. After using the filter for water of the three governorates; Cairo, Giza and Qualubia, the concentrations of the four target elements decreased to equal or less than the safe concentrations recommended by WHO, except Cd that exceeded the safe level of Giza`s water. Concerning Mg, resulted low concentrations of it in water of the five target areas and much lower than safe levels recommended by WHO and thus do not require water filter.

Key Words: Water pollution - Drinking water – Atomic Absorption Spectroscopy – Heavy metals.

Introduction

Drinking water consider the basis for continuation of the life of living organisms, where it involved in all metabolic processes. Water represents 65% of human's weight. Pure fresh water must be colorless, tasteless, odorless and contain important minerals in safe concentrations to be fit for drinking.

Water pollution is accompanied by changes in the natural, chemical, and biological characteristics of the water, making it unfit for drinking. The drinking water must be devoid of harmful heavy metals, radioactive materials, and disease-causing microorganisms (WHO, 2024a).

Types of water pollution may be chemical, biological, industrial, thermal or natural. Chemicals may be soluble or accumulable, that are the most dangerous Walker and Fitzsimmons (2019).

WHO (2014) reported that the rate of water pollution in Egypt is more than three times the global pollution rate and the rate of pollution is greater in Cairo than other governorates.

Moreover, Clinical and Environmental Toxicology Center at Kasr Al-Ainy Medicine stated that the share of Cairo Governorate was 35% of poisoning cases, 12% in Giza and 50% in Qalyubia.

Heavy metals have high density and their safe concentrations are usually low and harmless for human consumption when they do not exceed the safe concentrations recommended by WHO. The suitability of water can be determined by measuring levels of heavy elements and choose suitable methods for treating them when their concentration increases (WHO, 2024b).

When water is chemically polluted, its effect is toxic as a result of increasing the concentration of elements beyond the limits recommended by WHO. High levels of heavy elements, as Cu, causes pollution of drinking water and are toxic to cells. One of the best solutions to get rid of heavy metal contamination in drinking water is water purification system, as reverse osmosis and KENT RO water purifier`s system, that help in removing heavy metals from drinking water (Lydia *et.al.* 2023).

Iron is safe and non-toxic when it is consumed at very small levels.

Consuming large amounts of Ca without Mg leads to calcification of the arteries, cardiovascular diseases and kidney stones. High Mg-concentrations in human cause diarrhea, stomach upset, vomiting, nausea, abdominal cramps and irregular heartbeats that may reach heart attack, kidney damage, difficulty breathing and coma which may lead to death.

Cu and Pb-heavy metals contaminant drinking water and come from human industrial activities, components of pipes transporting drinking water and industrial waste. High concentration of Pb in aquatic habitat has toxic effect on aquatic organisms and symptoms of poisoning in human include anemia, wasting and loss of blood, blue gums, headache, loss of appetite, colic, impaired nerve function, muscle weakness and kidney failure.

Cd-poisoning in human causes damage of kidneys, bones, liver and blood, nausea, vomiting, abdominal pain, reduces calcium absorption causing osteomalacia, high blood pressure, lung and prostate cancer and disruption in kidney function leads to kidney failure.

Theoretical Framework

Water is the most precious resource in the world, integral to the survival of all life on Earth. Given that over 70% of the

planet's surface is covered by the stuff, it should perhaps logically follow that there is plenty to go around. However, various water pollution types render it unsafe for drinking, washing, bathing or swimming. Although not all forms of water contamination are manmade.

Surface water pollution is made up of seas, oceans, lakes, rivers and other waterways. These bodies of water can become contaminated from point sources, as industrial effluents and improper wastewater management systems, or non-point sources, as agricultural run-off, precipitation and seepage. This can contaminate the surface water and make it unsafe for humans, animals and plants. There are other types of water pollution including groundwater, chemical, microbiological, nutrient and suspended matter pollutions (Walker and Fitzsimmons, 2019).

In Egypt, the quality of Nile River-water had deteriorated continuously over several decades due to the dumping of untreated liquid waste (Abdel-Satar, 2005). The main sources of pollution in the Nile River are the discharge of untreated sewage into the river and industrial wastewater and heavy metals are considered the main pollutant of the Nile River, which comes from multiple human activities, including; industrial, agricultural and domestic liquid waste (Ezzat *et al.,* 2012).

Egyptian Giza Governorate is characterized by abundance of agricultural, industrial activities. Surface water samples were collected randomly and analyzed to confirm contamination with Fe, Cd and Pb and water contains higher concentrations of Pb and Cd near industrial areas than guidelines of WHO (Abu-Elela *et al,* 2021).

The presence of Mg and Fe in excessive quantities in freshwater harms skin cells and causes wrinkles and clogged skin pores, which leads to eczema or acne.

The most common sources of Pb in drinking water are lead pipes, taps that connect the house, where the problem is Cu taps with lead solder (Subramanian *et. al.* 1995).

Abu-Zaid *et. al.* (2020) found that the concentrations of Cu, Pb and Cd were 0.041, 0.014 and 0.002 mg./L in Mostorod and 0.032, 0.004 and 0.001 mg./L in Qalyubia respectively.

The toxicity limit of Fe, Cd and Pb has been estimated at 2, 0.003 and 0.01 mg./L respectively (WHO, 2009).

Gedamy *et. al.* (2012) evaluated the concentrations of Fe and Pb in water of El-Saff wastewater canal, Giza, Egypt that ranged from 0.604-18.68, and 0.0021-0.0166 mg./L respectively.

ADWQR (2021) declared that the levels of the metals; Fe, Cu, Pb and Mg in Cairo-waters were 0.105, 0.016, 0.004 and 6.200 mg. L respectively.

Hegazy *et. al.* (2021) estimated the average % of metal removal for Fe, Cu, Pb, Zn, and Co from River Nile-waters, after using Riverbank filtration (RBF), are 74.04%, 70.80%, 70.72%, 75.10% and 74.44% respectively.

Methods and Tools

The present water collected from five areas; three governorates: Cairo, Giza and Qalyubia, beside Mostorod and tape of chemical laboratory of Faculty of Education areas (**Fig. 1**). Then, the concentrations of four minerals; Mg, Fe, Pb and Cd; of these drinking waters had been evaluated before, in all five areas, and after passing through water filter "aqua8-type" (**Fig. 2**) only in Cairo, Giza and Qalyubia governorates.

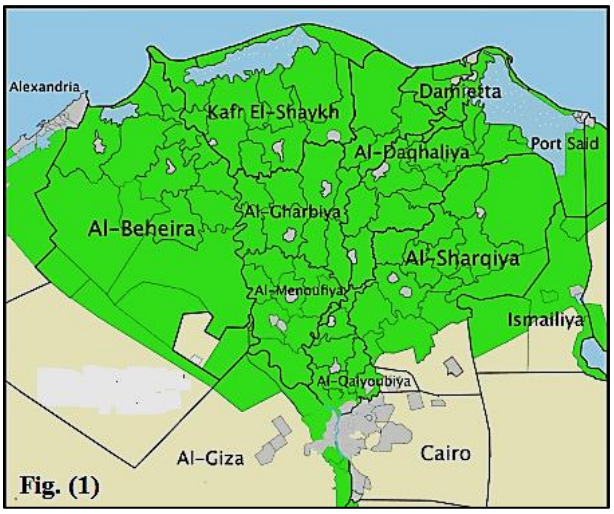

Fig. (1)


Fig. (2): Aqua-8-Filter

Estimating of concentrations of the target four minerals inside the collected drinking water had been achieved using Atomic absorption spectrometry (AAS) (Fig. 3):


Fig. (3) Atomic Absorption Spectrometry

The theory of AAS-method can be summarized as follows: The absorbed radiation passes through the water samples had been measured and radiation energy for each element has been calibrated, the quantity of each element can be determined by reading the resulting spectra. Then, the atoms absorb this radiation and move it to higher energy level. Photons of the light absorbed by the samples measured using a detector, that measures wavelengths of light transmitted by the sample and compares them to wavelengths that were originally passed through the sample. A special device processes the signals and determines the changes in the absorbed wavelength, which appear in the reading in the form of energy absorption peaks at separate wavelengths. The concentration is calculated based on the Beer-Lambert law, which states that the absorption is directly proportional to the concentration and the concentration is measured from the calibration curve Which was obtained using known concentration standards (Mohan *et al.* 1996).

Results of Research

The present results including estimating of concentrations of four elements; Mg, Pb, Cd and Fe; in five areas; Cairo, Giza, Qalyubia, Mostorod and a laboratory of faculty of Education, without (Figs. 4-7) and with filters (Figs. 8-11) and show that the Qalyubia-water contains the highest concentration of the elements before using the filters (Table 1). After using the filters in water of the three governorates, Cairo, Giza, Qalyubia (Figs. 8-11), the results show decreasing the concentrations of all four elements are equal or less than safe levels that recommended by WHO; that are 0.300, 0.050, 0.005 and 40 mg. L; except concentration of Cd of Giza-water. Concerning the resulting levels of Mg, they are very low, safe and no need using water-filter, ranged from 6.200–17.00, when compared to safe concentration that recommended by WHO (40).

Table (1): Concentrations of four target metals from five areas								
Metals / Areas	Cd		Fe		Pb		Mg	
	without filter	with filter	without filter	with filter	without filter	with filter	without filter	with filter
Cairo	0.005	0.005	0.040	0.030	0.070	0.040	10.00	9.000
Giza	0.008	0.007	0.030	0.010	0.040	0.010	8.000	6.200
Qalyubia	0.012	0.003	0.600	0.020	0.090	0.040	17.00	13.60
Mostorod	0.005		0.120		0.040		9.000	
Education College	0.007		0.020		0.020		8.000	

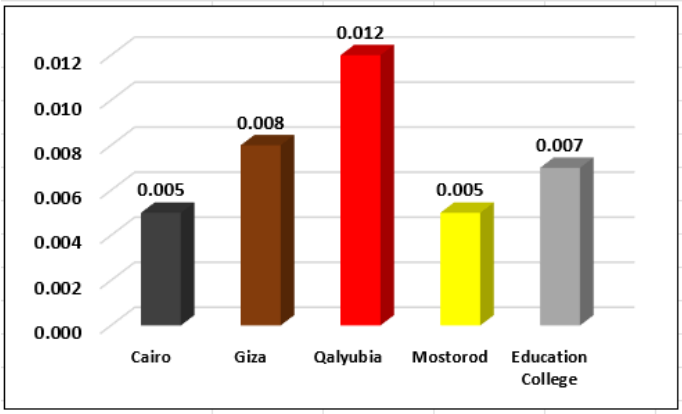

Fig. (4): Cd-concentration without filter.

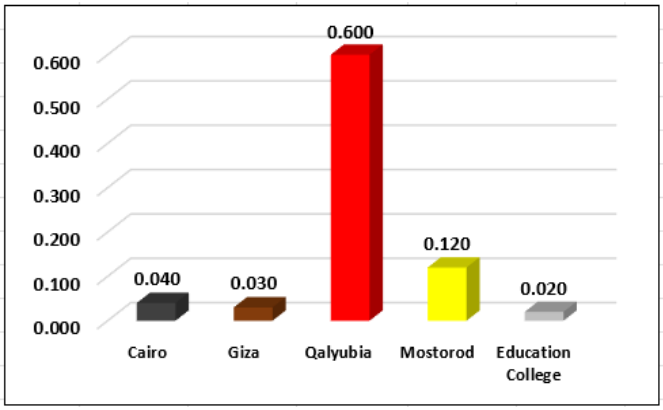

Fig. (5): Fe-concentration without filter.

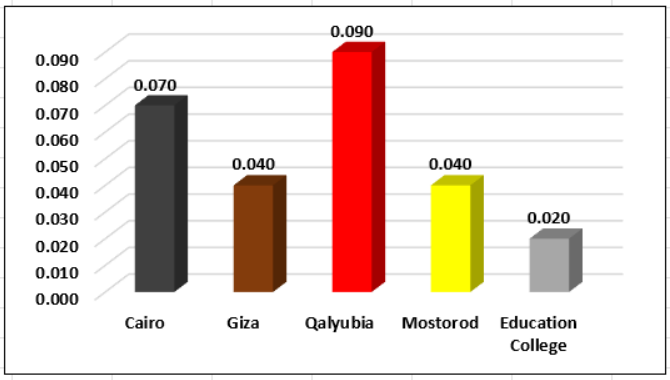

Fig. (6): Pb-concentration without filter.

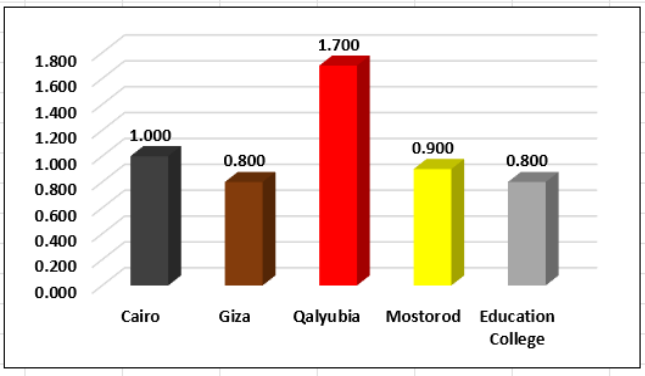

Fig. (7): Mg-concentration without filter.

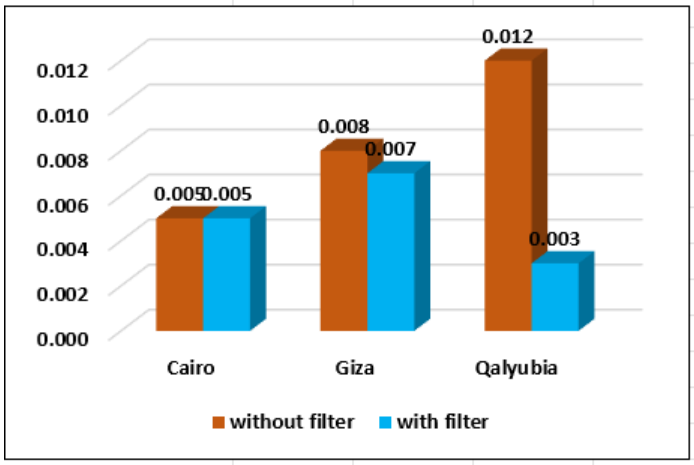

Fig. (8): Cd-concentration with and without filter.

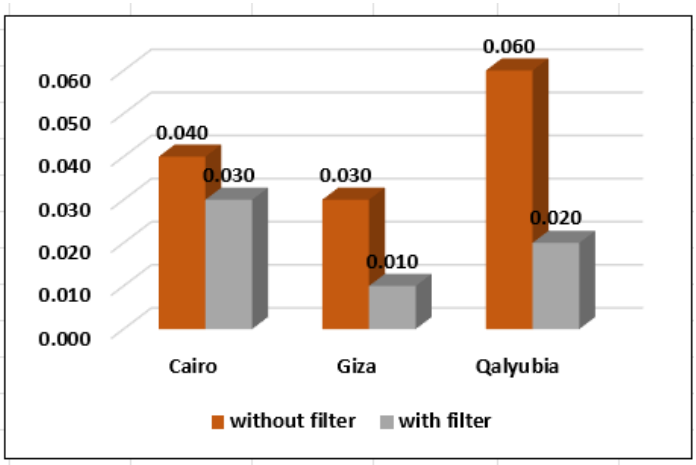

Fig. (9): Fe-concentration with and without filter.

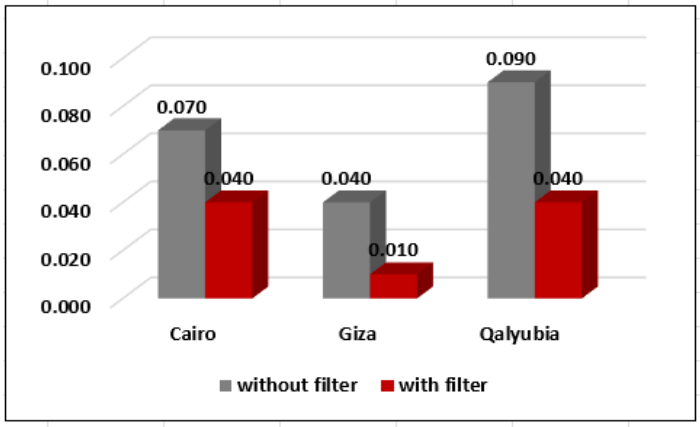

Fig. (10): Pb-concentration with and without filter.

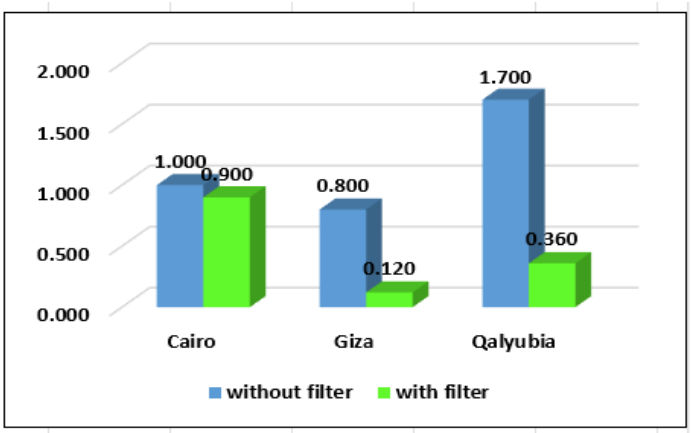

Fig. (11): Mg-concentration with and without filter.

Interpretation of Results

WHO reported in 2014 that the rate of water pollution in Egypt is more three times than the global pollution rates, especially in Cairo, Giza and Qalyubia governorates. For this reason, the present work was achieved in these three governorates.

Drinking water is considered the basis for continuation of the life of living organisms and thus the present work care about drinking water treatment using the different types of water-filters.

Concerning Cd, the higher level of it in Giza area (0.007 mg. L) than WHO-level (0.005 mg. L) after using the water-filter agrees with report of (Abu-Elela *et al,* 2021) that declared that Giza is characterized by abundance of agricultural, industrial activities. The result of Abu-Zaid *et. al.* (2020) estimated levels of Cd in both Mostorod and Qalyubia (0.002 and 0.001 mg. L. respectively). The present Cd-level (0.007) is safe after comparing it with WHO-level (0.005).

Concerning **Fe**, the level (0.030) was safe in the present work and is lower than WHO-level (0.300).

Respecting **Pb**, the level was safe in the present work (0.040) and is lower than WHO-level (0.050).

Regarding **Mg**-level in the present work is very low, safe and no need using water-filter (ranged from 6.200–17.00) after comparing with level of WHO (40).

Finally, we agree with result of Hegazy *et. al.* (2021) and recommend the using of Riverbank filtration, where this method estimates the average% of metal removal of metals, especially heavy metals, where they estimated the average% of both Fe and Pb from River Nile-water that are 74.04% and 70.72% respectively. We also recommend more continuous studies in the contamination of drinking water of house 'tapes and choose suitable filter in houses, companies and government agencies.

Conclusion

Drinking water is considered very important for the continuation of the life of living organisms. Therefore, the current research included the estimation of four elements; Fe, Pb, Cd and Mg; in drinking water in water of five areas; Cairo, Giza, Qalyubia, Mostorod and library of college of Education before and after it passes through the filters. The Qalyubia-water contains the highest concentration of all four target elements before using the filters. After using the filters in water of the three governorates, Cairo, Giza, Qalyubia, the results show decreasing the concentrations of all four elements are equal or less than safe levels that recommended by WHO; that are 0.300, 0.050, 0.005 and 40 mg. L; except concentration of Cd of Giza-water. Concerning the resulting levels of Mg, they are very low, safe and no need using water-filter, ranged from 6.200–17.00, when compared to safe concentration that recommended by WHO (40). Therefore, the present study recommends using Riverbank filtration and other types to remove or at least minimize the risks of contamination of heavy metals.

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