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Evaluation of the Levels of Haloacetic acids in Gharbiya Governorate, Egypt

Rafat Moustafa[*,1] , Ahmed Hesham[2]

[1]*El Gharbiya water company, Gharbiya, Egypt*
[2]*Basic Science department, Environmental studies and research Institute, Ain Shams University, Cairo, Egypt.*

E-Mail:*rafat.moustafa@outlook.com, Ahmedhasham83@outlook.com*
ORCID: 0000-0003-3017-7037 (Rafat Moustafa) & 0000-0002-0202-6664 (Ahmed Hesham)

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Abstract: The occurrence of haloacetic acids (HAAs) was studied in the drinking water samples from Gharbiya governorate water treatment plants and its water supply network that served more than 5 million people. Drinking water disinfection by-products are formed when a disinfectant reacts with natural organic matter and/or bromide/iodide present in a raw water source. Trihalomethanes and haloacetic acids are the two most prevalent classes of DBPs and are regulated by the US Environmental Protection Agency as well as being subject to World Health Organization guidelines due to their potential health risk. Drinking water samples were collected from 4 sites monthly over one year (2017-2018). The aims of the present study are to investigate the levels of HAAs in Gharbiya governorate (middle of Delta Egypt) drinking water. monochloroacetic acid ranged from 6.8 to 32.5 µg/L, dichloroacetic acid ranged from 9.8 to 43.7 µg/L, and the trichloroacetic acid ranged from 6.5 to 31.8 µg/L, the minimum values observed during winter 2018 and the maximum value observed during summer 2017., The HAAs species values were complying with the Egyptian standard (Ministerial Decree No.458/2007) and as well as WHO 2012) standards for drinking water.
Keywords: Haloacetic acids, DPBs, Gharbiya Governorate, Egypt, Environment, Pollution, Disinfection.

INTRODUCTION

Chlorination is an effective disinfection method in water treatment for inactivating microorganisms to safeguard the public health against waterborne diseases. However, reactions of chlorine with natural organic matter (NOM) in water may result in formation of harmful disinfection by-products (DBPs), such as trihalomethanes (THMs) and haloacetic acids (HAAs) [1, 2].

Disinfection by-products (DBPs) are regulated in many countries, due to their genotoxicity, mutagenicity and carcinogenicity [1, 2]. Trihalomethanes (THMs) and haloacetic acids (HAAs) are two major groups of carbonaceous DBPs (C-DBPs) that form during chlorination in drinking water treatment [3]. Natural organic matter (NOM) generally consists of humic substances in raw water and has been recognized as an important source of DBP precursors [3,4]. Consequently, developing efficient treatment processes for the removal of NOM and the reduction of DBP formation has received a lot of research interest [5,6].

To minimize the formation of DBPs, 'enhanced coagulation' and 'precipitative softening' processes have been introduced to increase the removal efficiency of NOM (the DBP precursors) by the United States Environmental Protection Agency (USEPA) in the Stage 1 Disinfectant and Disinfection By-products Rule in conventional water treatment processes [7].

MATERIALS AND METHODS

Water samples were collected from different parts of the governorate representing main distribution network of water supply. Sampling locations were shown in Figure (1). Total 48 sampling locations were sampled during the present study. Samples for HAAs analysis were collected in headspace-free borosilicate amber glass bottles with Teflon joint screw cap, containing 1.0 mL of 5% ammonium chloride as quenching solution to remove any residual chlorine. Temperature, pH and free chlorine were measured in the field. Once collected, samples were stored in the dark at 4°C and carried to the laboratory for analytical procedures. Measurements of free chlorine were measured in the field using the DPD4 and disk comparator. The DOC was analyzed in accordance with Standard Method 5310B[8].

A total organic carbon (TOC) analyzer (Model TOC-VCSH, Shimadzu, Tokyo, Japan) was used to determine the non-purgeable organic carbon according to the combustion catalytic oxidation/Non-Dispersive Infrared (NDIR) method. UV254 was analyzed in accordance with Standard Method 5910B

[*]*Corresponding E-mail: rafat.moustafa@outlook.com*

using a UV-Vis spectrometer (DR-5000, HACH) at 254 nm, analyzed in triplicate. The SUVA value was calculated as UV254 times 100 divided by the DOC concentration. All water samples were analyzed in triplicate. HAAs were analyzed using a gas chromatograph (Agilent HP 6890N) outfitted with a 63Ni electron capture detector (ECD), an auto-sampler and a Supelco EquityTM-5 column (30 m × 0.25 mm ID). Three replications of HAAs measurements were performed for each sample [8,9].

RESULTS & DISCUSSION

The data presented in (Figures 2, 3, 4 and 5), showed that, the seasonal variation of disinfection by-products (HAAs) in four water treatment plants (WTP) in El Gharbiya governorate.

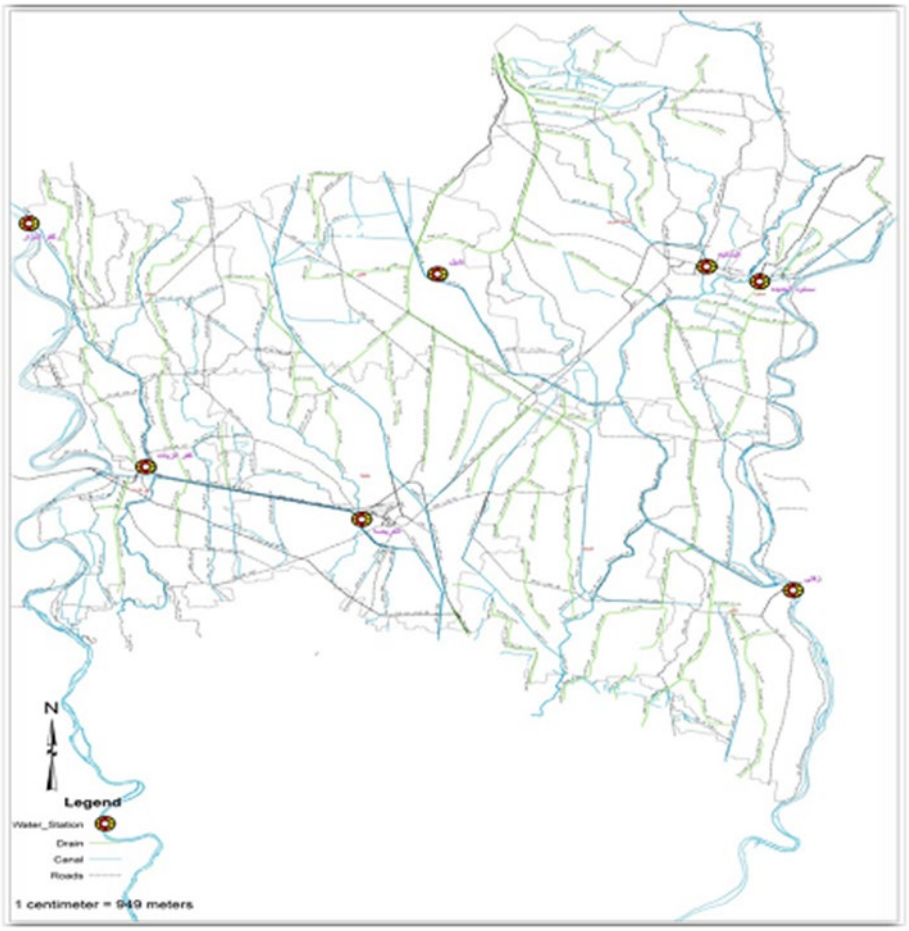

Figure 1. Sampling sites

El-Arida WTP

Monochloro acetic acid (MCAA) ranged from 8.8 to 24.9 µg/L, the minimum value observed during winter 2018 and the maximum value observed during summer 2017. Dichloroacetic acid (DCAA) ranged from 14.2 to 43.7 µg/L, the minimum value observed during winter 2018 and the maximum value observed during summer 2017, the trichloroacetic acid (TCAA) ranged from 9.5 to 31.8 µg/L, the minimum value observed during winter 2018and the maximum value observed during summer 2017as shown in Figure 2. The HAAs species values were complying with the Egyptian standard (Ministerial Decree No.458/2007) and as well as WHO (2012) standards for drinking water [5, 10].

A number of HAA occurrence surveys have been undertaken, and HAAs occurred at similar concentrations to THMs and in some cases a little higher and in some a little lower. Levels of HAA reported range from single figures up to the hundreds of µg L-1 but the median values tend to be in the range 20-40 µg L^{-1}. Given that the water sources, treatment and disinfection practices all vary across these surveys it is often difficult to compare them against each other but they do often allow us to see general trends. Disinfection consideration practices then any contact of organics with free chlorine is important and will contribute to DBP levels. When monochloramine is used as a disinfectant the levels

of HAAs found are significantly reduced, but even a short contact time with free chlorine leads to significant HAA levels [4,5].

Huaet al. (2008) investigated the use of different disinfectants and showed how in simulated distribution system tests using filtered water samples dosed with chlorine and chloramines, the formation of THM and HAA was 2-12 times higher when chlorine was used as the primary disinfectant than when using ClO_2. Ateset al.(2007) showed how even when ClO_2 was used as the main disinfectant the use of pre-chlorination led to HAAs levels that ranged from 13 to 52µg L-1 in the winter, and from 12 to 111 µg L-1 in the summer. The findings in the study was agreement with the studies conducted by both Atesetal.(2007) and Huaet al. (2008) [1,3].

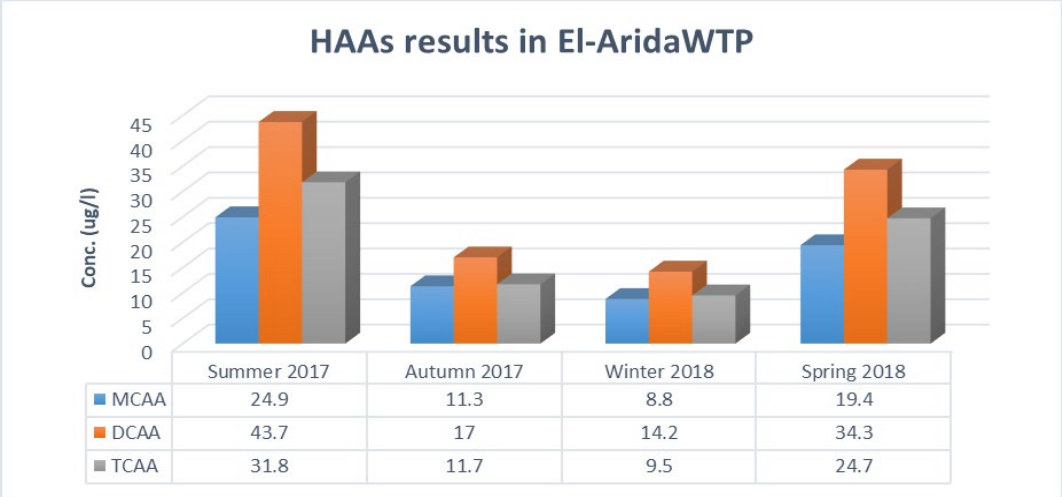

Figure 2. HAAs results in El-Arida WTP

El-mahala el-kobra WTP

Monochloro acetic acid (MCAA) ranged from 7.5 to 19.5 µg/L, the minimum value observed during winter 2018 and the maximum value observed during summer 2017. Dichloroacetic acid (DCAA) ranged from 11.3 to 37.6 µg/L, the minimum value observed during winter 2018 and the maximum value observed during summer 2017, the trichloroacetic acid (TCAA) ranged from 7.5 to 28.5 µg/L, winter 2018 and the maximum value observed during summer 2017 as shown in Figure 3. The HAAs species values were complying with the Egyptian standard (Ministerial Decree No.458/2007) and as well as WHO (2012) standards for drinking water [5, 10].

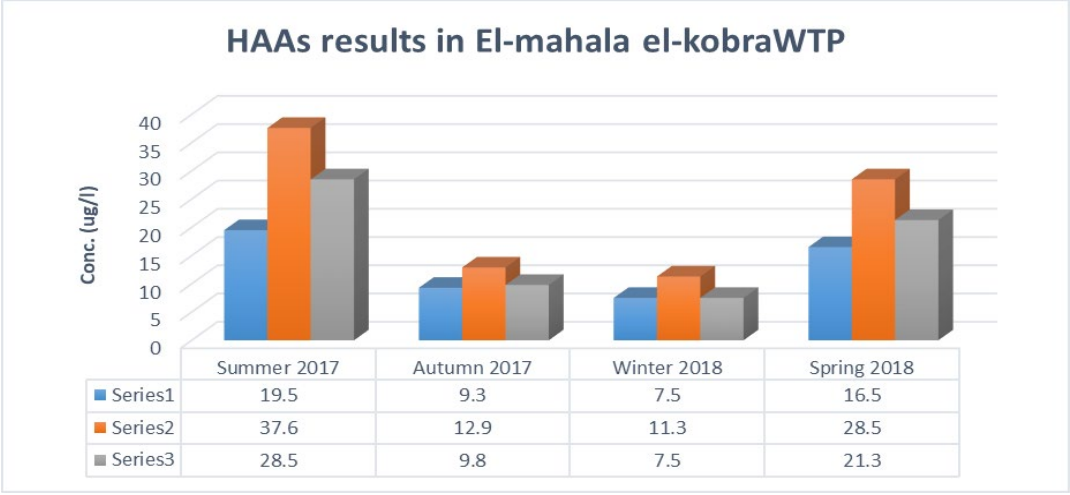

Figure 3. HAAs results in El-mahala el-kobra WTP

Zeftta WTP

Monochloro acetic acid (MCAA) ranged from 6.8 to 18.4 µg/L, the minimum value observed during winter 2018 and the maximum value observed during summer 2017. Dichloroacetic acid (DCAA) ranged from 9.8 to 34.5 µg/L, the minimum value observed during winter 2018 and the maximum value observed during summer 2017, the trichloroacetic acid (TCAA) ranged from 6.5 to 25.8 µg/L, the minimum value observed winter 2018 and the maximum value observed during summer 2017 as shown in Figure 4. The HAAs species values were complying with the Egyptian standard (Ministerial Decree No.458/2007) and as well as WHO (2012) standards for drinking water [5, 10].

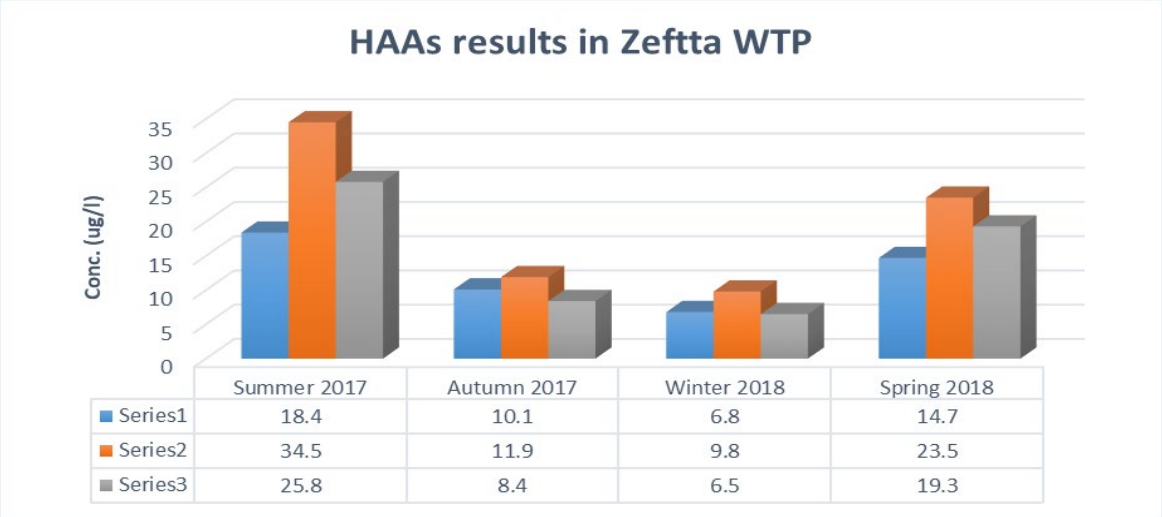

Figure 4. HAAs results in Zeftta WTP

Kafr el-zayat WTP

Monochloro acetic acid (MCAA) ranged from 9.9 to 32.5 µg/L, the minimum value observed during winter 2018 and the maximum value observed during summer 2017. Dichloroacetic acid (DCAA) ranged from 11.0 to 42.5 µg/L, the minimum value observed during winter 2018 and the maximum value observed during summer 2017, the trichloroacetic acid (TCAA) ranged from 8.9 to 31.8 µg/L, the minimum value observed during winter 2018 and the maximum value observed during summer 2017 as shown in Figure 5. The HAAs species values were complying with the Egyptian standard (Ministerial Decree No.458/2007) and as well as WHO (2012) standards for drinking water [5, 10].

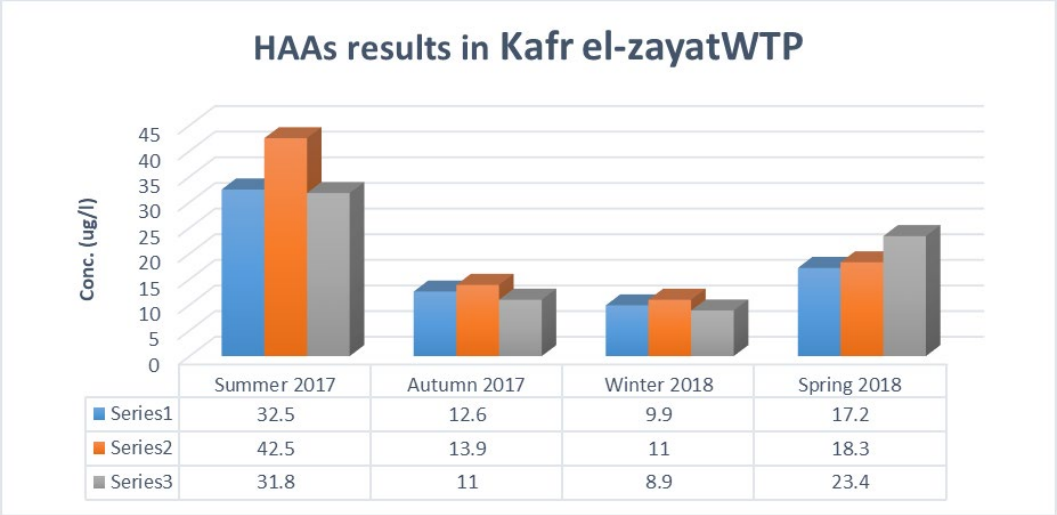

Figure 5. HAAs results in kafr el-zayat WTP

CONCLUSION

Present study found considerable variation in HAAs concentration between the four seasons. The HAAs species values were complying with the Egyptian standard (Ministerial Decree No.458/2007) and as well as the EPA (2012) and WHO (2012) standards for drinking water. The HAAs levels followed the general trend of higher concentrations in summer and autumn compared to winter and spring with large variations in the concentration level. It is difficult to identify the principal parameter(s) driving the HAAs formation for all the seasons in the presence of complex nature of source water NOMs matrix. A comprehensive monitoring program of the HAAs in the urban and rural water supply is recommended to facilitate the evaluation of principal factor(s) causing elevated levels of HAAs, which may cause adverse health effects.

RECOMMENDATIONS

Although the seasonal variation of HAAs formation was not pronounced in the survey data reported here, the different formation tendency according to water source are clear to see. Reservoir waters were more likely to form higher HAAs concentrations compared to river and borehole sources. This is likely to be due to the higher levels of NOM present in the form of soil derived organics in upland reservoirs which is not completely removed during treatment. In lowland reservoirs, algal-derived organics that are often recalcitrant to treatment contribute to the increased HAA formation observed. Bromine incorporation is greater for the lowland sites compared to the upland sites, which is expected as lowland waters tend to have higher bromide concentrations than upland waters.

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