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Evaluation of Trihalomethanes Levels in Gharbiya Governorates Drinking Water

Ali M Hassan[1], Ali M Abdullah[2]* and Rafat Moustafa[3]

[1]Chemistry Department, Faculty of Science, El Azhar University, Cairo, Egypt
[2]Reference Laboratory for Drinking Water, Holding Company for Water and Wastewater and IGSR, Alexandria University, Alexandria, Egypt
[3]El Garbyia water company, Garbyia, Egypt

Abstract

The occurrence of trihalomethanes (THMs) 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 samples were collected from 7 sites monthly over one year (2012-2013). The aims of the present study are to investigate the levels of THM in Gharbiya governorate (middle of Delta Egypt) drinking water. THMs ranged from 43.69 to 95.94 µg/L, the minimum value observed during winter 2013 and the maximum value observed during summer 2013, The THM and its species values were complying with the Egyptian standard (Ministerial Decree No.458/2007) and as well as WHO (2012) standards for drinking water.

Keywords: Trihalomethanes; Drinking water; Gharbiya governorate; levels of THM

Introduction

Chlorination is the most accepted disinfectant throughout the world because of its economical availability and effectiveness against the waterborne pathogens. Chlorination worked effectively against the microorganisms and provide safeguard against several waterborne diseases [1,2] on the other hand, it reacts with natural organic matters (NOMs) to form disinfection by-products (DBPs). Studies have shown a relationship between long-term exposure to DBPs and increase risk of cancer and adverse reproductive outcomes [1,2]. Trihalomethanes (THMs) are the most abundant DBPs [3,4]. THMs constitute a major class of DBPs, including chloroform ($CHCl_3$), bromodichloromethane ($CHCl_2Br$), chlorodibromomethane ($CHClBr_2$) and bromoform ($CHBr_3$). Since THMs concentration in water is a serious health concern and United States, European Union (EU) and World Health Organization (WHO) regulated THMs in public water supplies [5]. Several factors in addition to NOMs influenced the formation of THMs including the nature of source water, amount and time of contact of chlorine, levels of total organic compounds (TOC), temperature and pH etc. [5,6]. Water from water treatment plant and tap water is generally used not only for drinking but also for washing, cleaning, cooking, showering, and bathing. The water constituted of contaminants i.e., THMs was potential to expose through ingestion during drinking or bathing, contact with skin as dermal absorption and even inhalation of the risk compounds. Several studies were estimated the lifetime cancer risk and non-carcinogenic risk for THMs through muti-pathway exposure routes. The risk assessment for water was commonly calculated to ingestion exposure to toxic compound. Presently, the other routes of exposure in dermal and inhalation exposure may be more important than direct ingestion exposure [7,8]. In Hong Kong, the researcher reported that the cancer risk and hazard index of THMs from tap water that exposed through ingestion route higher than dermal and inhalation routes. The another research study also reported that the THMs in Beijing and Canada drinking water were higher risk through oral ingestion than through other two pathway (dermal and inhalation) and female was more exposed of THMs than male. The reported level of THMs in drinking water supply in Istanbul stated that oral ingestion was found at highest concentration and chloroform was mostly detected in water [7,8]. However, the study in Taiwan revealed that the Chloroform in water was highest risk from the inhalation exposure during shower and dominated to the total risk of THMs. This study also showed that exposure from THMs dermal absorption is not significant comparing to oral and inhalation exposure. The importance of THMs inhalation exposure route was also reported in India that accounted of 80-90% of the total risk followed by oral exposure and dermal absorption. Chloroform was found to be major THMs. One study in Thailand was investigated the THMs in tap water and swimming pool water in Nakorn Pathom. Results showed that the concentration of THMs in swimming pool water was higher than in tap water and cancer risk from skin exposure while swimming was 94.18% of the total risk. The three exposure route of exposure may be attributed to different concentration and species of THMs present in water [7,8]. The variation of THMs can also influence temporally and seasonality influenced the THMs formation process. Different studies on seasonality dependency showed variable results in summer and winter [6,9].

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 THMs analysis were collected in headspace-free borosilicate amber glass bottles with Teflon joint screw cap, containing 1.7 mL of 10% sodium thiosulfate 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. AEPA method 551.1 was used

***Corresponding author:** Ali M Abdullah, PhD, Technical Support Manger, HCWW, Alexandria, Egypt, Tel: 00201229248037; E-mail: dr2252000@dr.com

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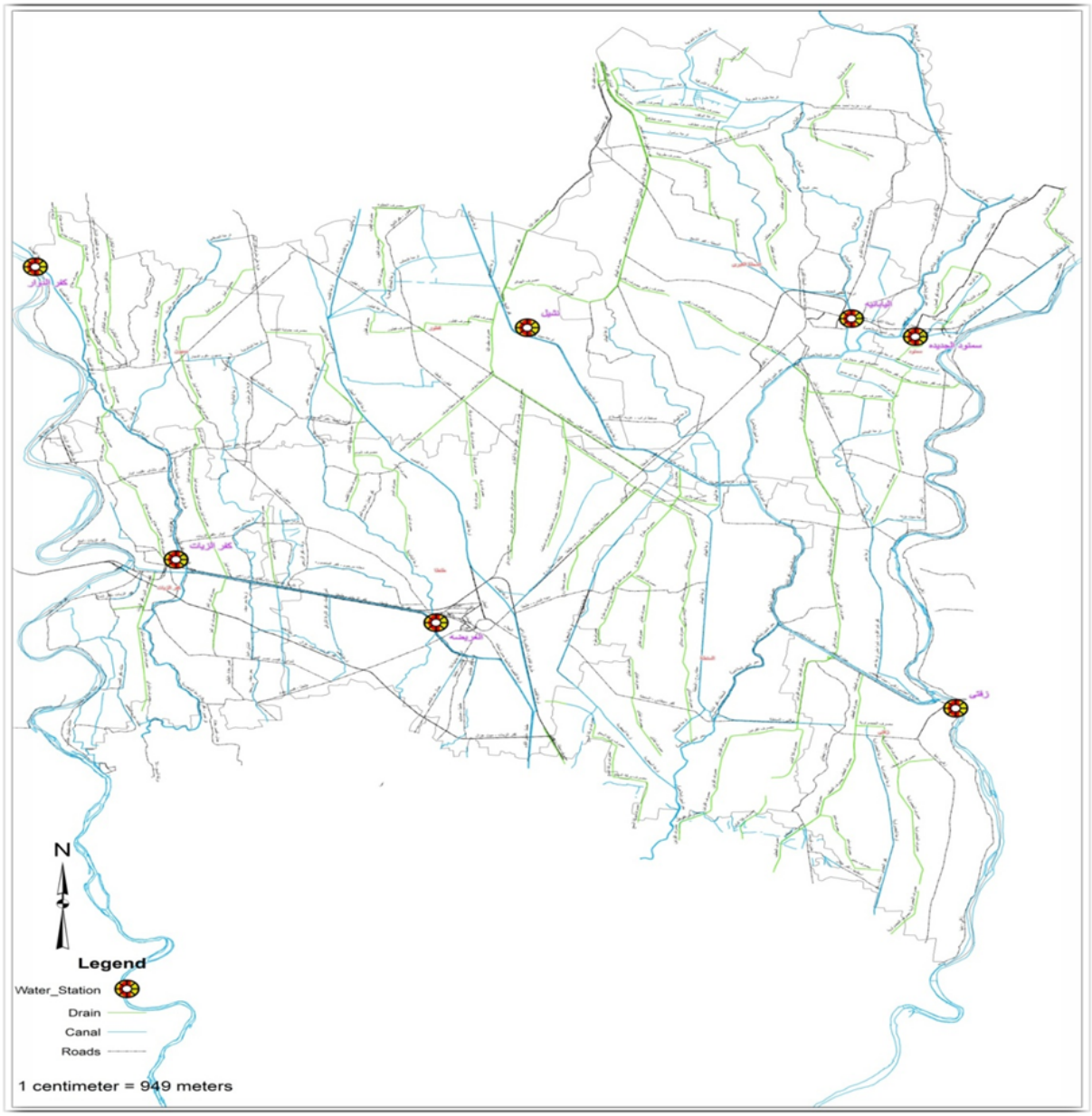

Figure 1: Gharbiya sampling sites.

to determine the THMs ($CHCl_3$, $CHCl_2Br$, $CHClBr_2$ and $CHBr_3$). 4 mL of was added to 25 mL of sample in 40 mL glass vials. The upper phase layer of n- Pentane was separated by manual shaking for 1 minute and 1 µL Pentane layer was injected into the CP-3800 gas chromatograph (GC). The GC was equipped with DB 5 (30 m, 0.32 mm i.e., 0.25 µm film thickness) chromatographic column and the analytical conditions were set as: injection split ratio 1:20; oven temperature 30°C for 5 min, 30-120°C at 6°C/min; carrier gas Helium 1.0 mL min^{-1}, make-up gas N_2 60 mL min^{-1}; detector (ECD) temperature 300°C. DB-1301 capillary column was used for the confirmation of the THM analysis. Field blanks were used to determine any background contamination. Method blanks and spiked blanks were analyzed. The recoveries obtained for $CHCl_3$, $CHCl_2Br$, $CHClBr_2$ and $CHBr_3$ were 93-109, 88-106, 92-111, 96-108 and detection limits (four compounds) 1.0 µg L^{-1} respectively were ensured by the analytical procedure [10].

Results and Discussion

The data presented in (Tables 1 and 2) and (Figures 2, 3, 4 and 5), showed that, the seasonal variation of disinfection by-products (THM) in four water treatment plants (WTP) in El Garbyia governorate.

El-Arida WTP

Chloroform ranged from 31.47 to 63.22 µg/L, the minimum value observed during winter 2013 and the maximum value observed during summer 2013. BDCM (Bromodichloromethane) ranged from 24.62 to 28.01 µg/L, the minimum value observed during winter 2013 and the maximum value observed during summer 2013. DBCM

Site	El-Arida WTP					El-mahala el-kobra WTP				
	(µg/L)									
Parameter / Season	$CHCl_3$	BDCM	DBCM	$CHBr_3$	THM	$CHCl_3$	BDCM	DBCM	$CHBr_3$	THM
Autumn	40.39	25.80	7.41	0.24	73.83	22.86	21.97	7.35	0.00	52.18
Winter	31.47	24.62	6.80	0.00	62.89	18.56	18.71	6.58	0.00	43.85
Spring	47.83	26.38	4.78	0.00	78.98	26.43	18.79	3.74	0.00	48.96
Summer	63.22	28.01	4.71	0.00	95.94	33.32	22.49	4.29	0.00	60.10

Table 1: THM results in El-Arida and El-mahala el-kobra WTPs.

Site	Zefta WTP					kafr el-zayat WTP				
	(µg/L)									
Parameter / Season	$CHCl_3$	BDCM	DBCM	$CHBr_3$	THM	$CHCl_3$	BDCM	DBCM	$CHBr_3$	THM
Autumn	42.36	23.37	8.35	0.00	77.08	31.81	25.65	6.64	0.00	64.10
Winter	20.71	14.89	5.06	0.00	40.69	24.09	18.24	4.64	0.00	46.97
Spring	34.35	19.55	5.09	0.00	58.93	31.28	20.97	5.63	0.00	57.87
Summer	35.98	22.11	6.75	0.00	64.83	45.68	24.73	4.45	0.00	74.86

Table 2: THM results in Zefta and kafr el-zayat WTPs.

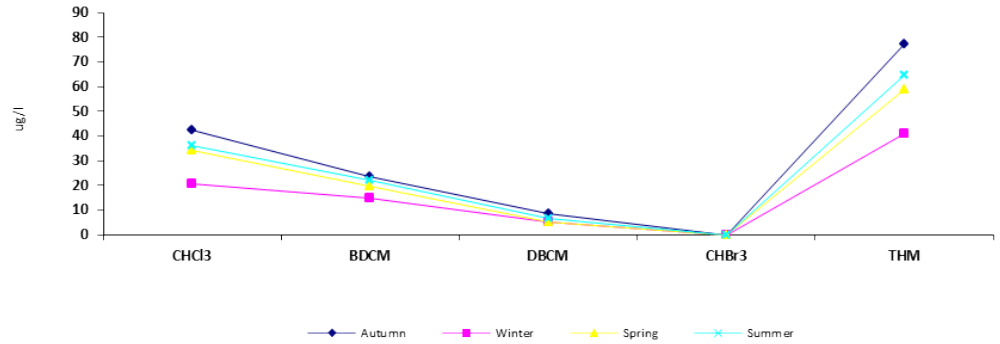

Figure 2: THM in El-Arida WTP.

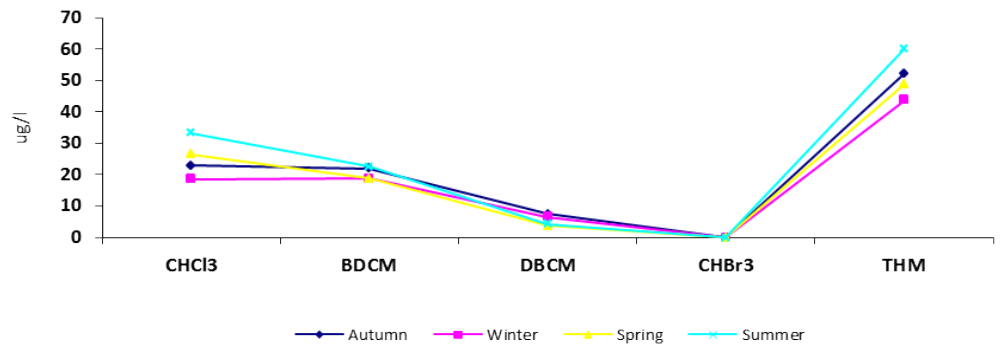

Figure 3: THM in El-mahala el-kobra WTP.

(Dibromochloromethane) ranged from 4.71 to 7.41 µg/L, the minimum value observed during summer 2013 and the maximum value observed during autumn 2012. Bromoformranged from 0.0 to 0.24 µg/L, the minimum value observed during most year months and the maximum value observed during autumn 2012. Total THM ranged from 62.89 to 95.94 µg/L, the minimum value observed during winter 2013 and the maximum value observed during summer 2013 as shown in Table 1 and Figure 2. The THM and its species values were complying with the Egyptian standard (Ministerial Decree No.458/2007) and as well as WHO (2012) standards for drinking water [11,12].

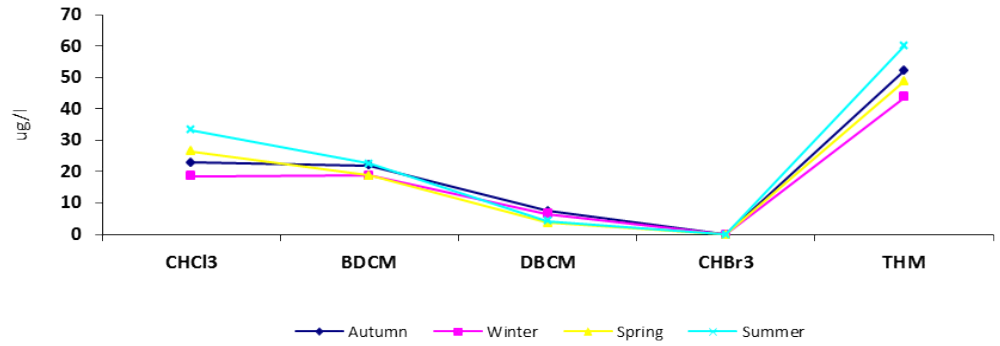

Figure 4: THM in Zefta WTP.

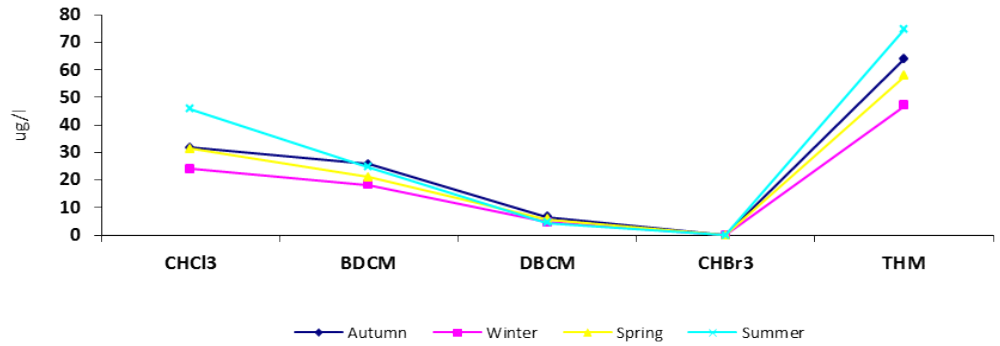

Figure 5: THM in kafr el-zayat WTP.

El-mahala el-kobra WTP

Chloroform ranged from 18.56 to 33.32 µg/L, the minimum value observed during winter 2013 and the maximum value observed during summer 2013. BDCM ranged from 18.71 to 22.49 µg/L, the minimum value observed during winter 2013 and the maximum value observed during summer 2013. DBCM ranged from 3.74 to 7.35 µg/L, the minimum value observed during spring 2013 and the maximum value observed during autumn 2012. Bromoform did not detect during the present study. THM ranged from 43.85 to 60.10 µg/L, the minimum value observed during winter 2013 and the maximum value observed during summer 2013 as shown in Table 1 and Figure 3. The THM and its species values were complying with the Egyptian standard (Ministerial Decree No.458/2007) and as well as WHO (2012) standards for drinking water [11,12].

Samanood WTP

Chloroform ranged from 27.55 to 41.97 µg/L, the minimum value observed during winter 2013 and the maximum value observed during autumn 2012. BDCM ranged from 22.85 to 29.75 µg/L, the minimum value observed during summer 2013 and the maximum value observed during autumn 2012. DBCM ranged from 4.4 to 8.97 µg/L, the minimum value observed during summer 2013 and the maximum value observed during autumn 2012. Bromoform did not detect during the study. THM ranged from 57.33 to 80.68 µg/L, the minimum value observed during winter 2013 and the maximum value observed during autumn 2012 as shown in Table 2 and Figure 4. The THM and its species values were complying with the Egyptian standard (Ministerial Decree No.458/2007) and as well as WHO (2012) standards for drinking water [11,12].

Zefta WTP

Chloroform ranged from 20.71 to 42.36 µg/L, the minimum value observed during winter 2013 and the maximum value observed during autumn 2012. BDCM ranged from 14.89 to 23.37 µg/L, the minimum value observed during winter 2013 and the maximum value observed during autumn 2012. DBCM ranged from 5.06 to 8.35 µg/L, the minimum value observed during winter 2013 and the maximum value observed during autumn 2012. Bromoform did not detect during the study. THM ranged from 40.69 to 77.08 µg/L, the minimum value observed during winter 2013 and the maximum value observed during autumn 2012 as shown in Table 2 and Figure 5. The THM and its species values were complying with the Egyptian standard (Ministerial Decree No.458/2007) and as well as WHO (2012) standards for drinking water [11,12]. The THM formation generally favoured by high temperature, chlorine residue and source water natural organic matters composition (NOMs) [6,9,13]. The observed seasonalvariation of THMs was consistent with earlier studies reported maximum THM formation in summer [9,13,14]. $CHCl_2Br$ and $CHClBr_2$ exhibit inconsistent higher mean seasonal variations in winter and spring than summer and autumn (Figures 2, 3, 4 and 5). These higher mean values in winter can be attributed to characteristics of natural organic matter and changes inthe nature of THMs precursors in the source water [13,14].

Conclusion

Present study found considerable variation in THM concentration between the four seasons. The THM and its 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 THMs level 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 THMs formation for all the seasons in the presence of complex nature of

source water NOMs matrix. A comprehensive monitoring program of the THMs in the urban and rural water supply is recommended to facilitate the evaluation of principal factor(s) causing elevated levels of THMs, which may cause adverse health effects.

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