Study Effects of Disinfection products in wastewater for Medical City on Tigris River

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Abstract

This study's focus open the presence of disinfection by-products like trihalomethanes (THMs) compounds in wastewater of Medical City at the point where these by-product release to Tigris and to examine seasonal variations in some physicochemical parameters of the river in order to assess the effects of pollutants from the Medical City hospital on the Tigris River in Iraq. The study carried out from October 2021 to August 2022. The sample were collected from four stations along the Tigris River in Iraq were used to gather water samples, and the results revealed that the measurements of turbidity, electrical conductivity (EC), biological oxygen demand (BOD), total dissolved solids (TDS), total organic carbon (TOC), and total trihalomethanes (TTHMS) (165, 1809, 7.6, 1182, 50.9, 87.6) ppm respectively. In station 2 the results illustrated higher than those of other stations in most seasons during the study period. The Oxygen Demand (OD) appeared to be lower in station 2 than those in other stations. These maximum results mostly exceed the acceptable upper limit for WHO and Iraqi criteria for river system maintenance. Also, the results showed that mean concentrations of the TTHM compounds showed varied with seasonal variations during the study period. The values of TTHMs rise with a high proportion of TOC, and Temperature increases. Untreated sewage discharges from Medical City hospital contaminated the water in the Tigris River.

Keywords: Pollution, THMs, Physio-Chemical Characteristics and Tigris River.

دراسة تأثير منتجات التطهير في مياه الصرف الصحي لمدينة طب بغداد على نهر دجلة

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الخلاصة

ركزت الدراسة غلى تحديد وجود نواتج ثانوية للتطهير مثل مركبات ثلاثي الهالوميثان (THMs) في مياه الصرف الصحي وفحص الاختلافات الموسمية في بعض المعايير الفيزيائية والكيميائية للنهر لمياه نهر دجلة في نقطة رمي مياه الصرف الصحي لمدينة طب بغداد. الدراسة نفذت من أكتوبر 2021 إلى أغسطس 2022. حددت أربع محطات على طول نهر دجلة في العراق لجمع عينات المياه، وكشفت النتائج أن قياسات العكارة والتوصيل الكهربائي (EC) والطلب البيولوجي للأكسجين (BOD) والمواد الصلبة الذائبة الكلية (TDS) والكربون العضوي الكلي (TOC) ومجموع ثلاثي الهالوميثان (TTHMS) هي (165، 1809، 7.6، 1182، 50.9، 87.6 على التوالي) في المحطة 2 كانت أعلى من تلك الموجودة في المحطات الأخرى في معظم المواسم خلال فترة الدراسة. بدا أن قيمة الطلب على الأكسجين (OD) أقل حيث بلغت 2.2 في المحطة 2 من تلك الموجودة في المحطات الأخرى. وتجاوزت هذه النتائج في الغالب الحد الأعلى المقبول لمعايير منظمة الصحة العالمية والعراق لصيانة نظام النهر. كما أظهرت النتائج أن متوسط تركيزات مركبات TTHM أوضحت تباينًا مع التغيرات الموسمية خلال فترة الدراسة. وترتفع قيم TTHMs مع ارتفاع نسبة TOC وارتفاع درجة الحرارة. أخيرا يتضح من هذه النتائج ان تصريفات مياه الصرف الصحي غير المعالجة من مستشفى مدينة الطب تلوث المياه في نهر دجلة.

الكلمات المفتاحية: التلوث، ثلاثي ميثيل هيدروكلوريد، الخصائص الفيزيائية والكيميائية ونهر دجلة.

Introduction

Water pollution is a major environmental issue, it is considered polluted when its physical, biological, and chemical qualities have deteriorated due to anthropogenic or natural activity (Vardhan *et al*.,2019). The Tigris River serves as Baghdad's primary source of drinking water, fish aquaculture, and agricultural water resources. Tigris River pollution with toxic chemicals or substances has been a significant environmental concern and a significant public health issue in Iraq. (Hassan and Mahmood, 2018). One of the major environmental problem putting by hospital effluents is their discharge, in the same way as the urban classic effluents, towards the urban sewer network without preliminary treatment (Cidlinová *et al.*, 2018). There is a similarity between hospital wastewater and household wastewater, but it is characterized by containing hazardous many compounds and microorganisms including bacteria, viruses, and hazardous chemicals and materials sterilized in addition to radiation development laboratory waste, which is characterized by the presence of chemicals toxic (Al Aukidy *et al*., 2017). Hospitals generate a large amount of wastewater that contains different varieties of pollutants (Verlicchi *et al*., 2012). Kanama *et al.* (2018) mentioned that hospital wastewater consists of pathogens that are excreted from human bodies through urine and feces and often end up in sewer systems, which remain the major path for these contaminants to enter municipal sewage systems. Hospital effluents have been reported to contain tens to several hundreds of micrograms per liter concentrations of antibiotics, cytostatic, and other drugs. In some low-flow sewer networks, hospital effluents account for >80 % of all pharmaceuticals and personal care products in the network load (Iweriebor *et al.*, 2015). Other routes for emerging contaminants entering into HWW include the direct disposal of unused or expired drugs, landfill leachates, and the application of sewage sludge to ensure soil fertility. Many studies have reported that hospitals release untreated or inappropriately treated waste containing pharmaceuticals and toxic chemicals into ambient aquatic environments (Khan *et al*., 2021). The wastewater of Baghdad Medical City hospital is released directly into the Tigris River without adequate waste treatment. The quality of the river water in Baghdad was classified as "very poor" (Al-Obaidy *et al.*,2016). Chemical compounds formed as disinfection by-products (DBPs), when found in wastewater affect the quality of the Tigris River (Mensoor and Said, 2018). This compound poses a serious threat to water quality, aquatic ecosystems, and human health, when dumped into rivers (Cidlinova *et al*.,2018). DBPs are chemical combination compounds that are produced when natural organic matter (NOM) in the water interacts chemically with disinfectants. Nearly all-natural surface waters include NOM, a complex of organic material and it is produced from the decaying of trees remnant sand animal materials or what is overall known as the Humus (Baghoth, 2012). The disinfection by-products such as THM found in wastewaters are a genotoxic and potential contributing factor to malignancies seen in recent decades (Kocak, 2015). The aim of this study is to investigate disinfection by-products in wastewater from Baghdad Medical City and measure Trihalomethanes

(THMS) with Gas Chromatography. It also aims to examine the impact of Medical Cit's effluent on the physiochemical, characteristics of the Tigris River.

Materials and Methods

Study Area

One of Iraq's largest and most advanced hospitals, Baghdad Medical City is located in Bab Al-Muadham. It is situated between Bab Al-Muadham bridge and Sarafiya bridge on the Tigris river's east bank (Rusafa side) (Iraqi Ministry of Environment, 2009). It discharges its waste untreated right into the Tigris River. Daily, once to twice. The first station, which served as the control for the study, was chosen because it was 1000 meters away from the Medical City Complex. The second station represents the river outflow from Medical City. The third station is located 100 meters after the second station. The fourth station is placed 1500 meters after the third station.

Collection of Samples

Seasonal samples were taken from the four stations marked on the map (Figure 1). The samples were taken from surface water at a depth of about 10-20 cm approximately from October 2021 to August 2022, from the four locations with three replicates, 250 ml sterilized dark Winkler bottles were used for Biological Oxygen Demand, and Dissolve Oxygen, these bottles were kept in a cool box until they were delivered to the laboratory at a period that did not exceed three hours, sterilized plastic bottles used for THMS, physiochemical analysis (APHA, 2012).

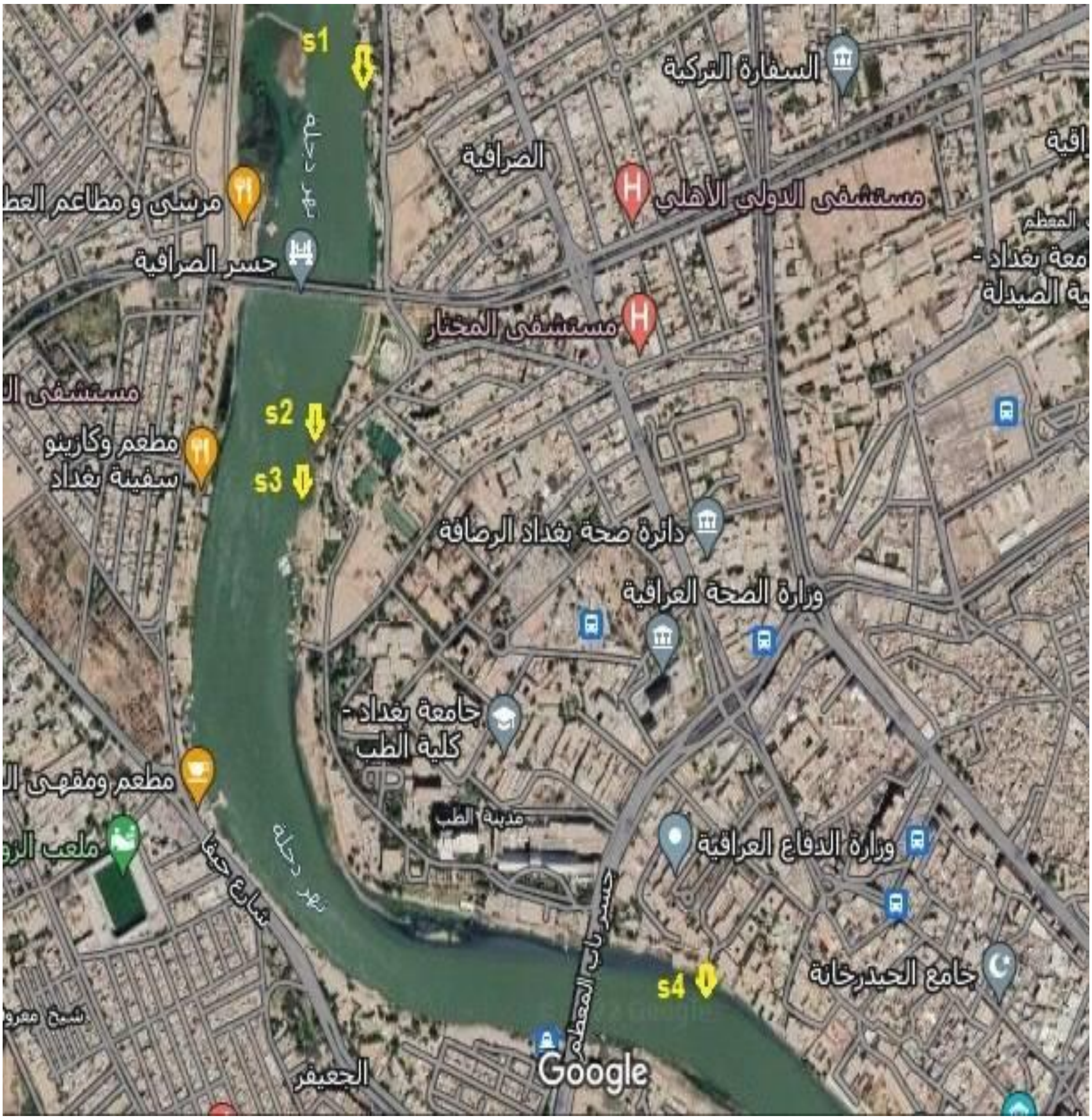

Fig. (1) Tigris river sampling locations are shown on a map from (Google Earth Pro).

Physico-Chemical Measurements

The turbidity was measured by using the turbid meter/ HACH/ USA device reading taken from the device in the Nephelometric Turbidity Unit (NTU). A portable conductivity meter (µs/cm) is used to test electrical conductivity. Bench-top dissolved oxygen meters (HI2400-01, U.S.A.) were used to measure the dissolved oxygen (DO), and the findings were expressed in mg/L. Winkler's method was used to measure the biochemical oxygen demand (BOD_5), and the findings were given in mg/L. (Standard Methods, 2005). Four total trihalomethanes (TTHMs)—chloroform (CHBr3), bromodichloromethane (CHBrCl2), dibromochloromethane (CHBr2Cl), and bromoform (CHBr3)—were determined using gas chromatography (GC) equipped with an electron capture detector (ECD) and a headspace sampler (AOC-5000). The results of TTHM were expressed in ppm. The TOC and TTHM determination procedure in Standard Method No. 5310C APHA (2012).

Statistical Analysis

Least Significant Difference (LSD) test (ANOVA) was used to discover significant differences between means using the Statistical Analysis System (SAS) 2012 application.

Results and Discussion

Turbidity

The results indicated that the greatest mean turbidity value was 165 ± 4.0 NTU in the winter season at station 2, whereas the lowest mean turbidity value was 9.4 ± 0.9 NTU in the summer season at station 1(Fig. 2). The statistical analysis revealed significant differences between stations at ($P \leq 0.05$) except station 1 and station 4, and significant differences at ($P \leq 0.05$) between seasons (Table 1). It measures the amount of small suspended matter in water that is brought on by colloidal particles like clay, non-living organic particulates, plankton, and other tiny creatures. and the Nephelometric Turbidity Unit (NTU) is typically used to express it. (Lako *et al*., 2012). Soil erosion in the neighboring catchment and significant input of suspended particles from untreated hospital sewage were blamed for the winter's heightened turbidity. The main causes of the increased turbidity are surface runoffs and household garbage, and their mobility prevented suspended materials from precipitating (Gangwara *et al*., 2012). The results a not within the allowable range for both WHO (2004) and Iraqi standards of river water 1967 No. (25), for some seasons.

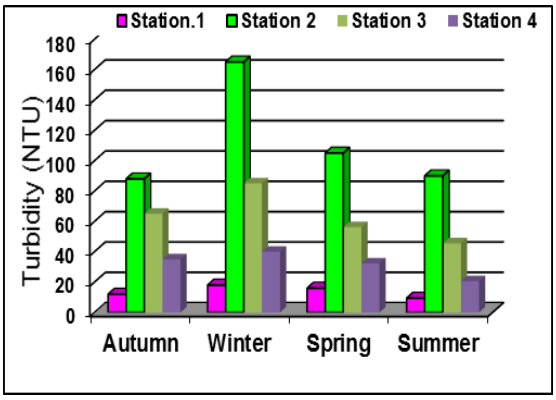

Fig. (2) seasonal variation of turbidity in Tigers River during the study period.

Electrical Conductivity (EC):

It is a measure of the ability of water to carry electric current and it is sensitive to variations in dissolved solids, mostly mineral salts (Ezzat *et. al*., 2012. The results indicated that the greatest mean EC value was 1809 ± 15.0µs/cm, in the summer season at station-2. And the mean EC value at its lowest was 610 ± 9.0 µs/cm in the spring season in station-1 (Fig. 3). While the statistical analysis revealed a significant difference between seasons and stations for E.C. at ($P \leq 0.05$). (Table 1). However, the EC values increased during autumn and summer and reduced during winter and spring which might be due to the high temperature during summer and autumn in Iraq which led to increased evaporation, then an increase in salts concentration so as the increase of many pollutants' concentration. (Wahab ,2010; Dar *et al*., 2010).

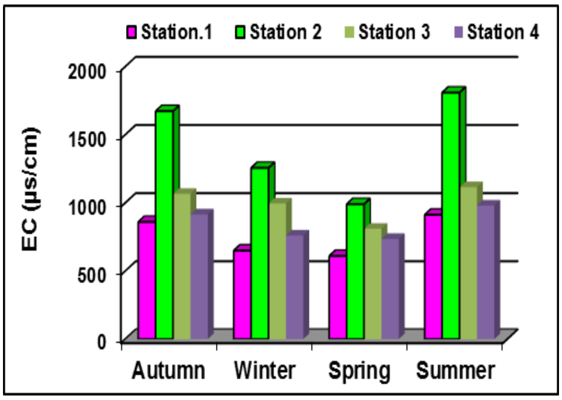

Fig.(3) Seasonal variation of EC in Tigers river during study period.

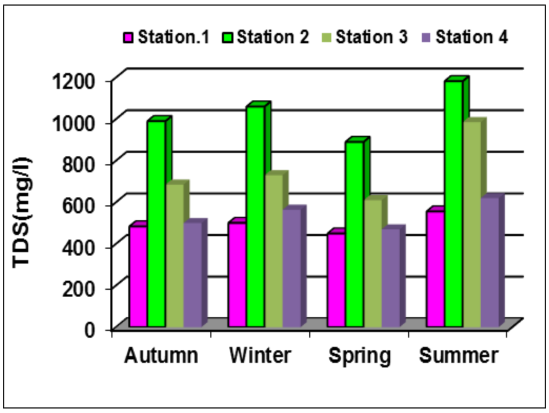

Fig. (4) Seasonal variation of TDS in Tigers River during the study period.

Total Dissolved Solids (TDS):

The results showed the highest mean value for TDS was 1182±20.7 mg/l in summer at Station-2, and the lowest mean value was 450 ±10.4 mg/l in spring at station-1(Fig. 4). The statistical analysis demonstrated a significant difference between seasons at ($P \le 0.05$) and significant differences among stations at ($P \le 0.05$) except for station 1.

It is the phrase used to describe the inorganic salts and small amount of organic matter present in solution in water. (Ferdous, *et al.*,2019). The higher value in the summer season may result from a rise in dust storms and a rise in the rates of dry fallout into surface water resources (Al-Sudany, 2012), The lower value in the spring season may be due to the sluggish decomposition rate, sedimentation of suspended particles, and dilution factor (Imnatoshi and Sharif, 2012). For some seasons, the results fall outside of the acceptable range for both the WHO (2004) and Iraqi stander of river water 1967 No. (25).

Dissolved Oxygen (DO)

The findings revealed that the highest mean DO was 10.8 ± 0.5 mg/l at station-1in the winter season, and the lowest mean value of DO was 2.2 ± 0.1 mg/l at station-2 in the summer season (Fig. 5). The DO results from station-2 are lower than other stations because of the high discharge of sewage. Also, statistical analysis showed significant differences at ($P \le 0.05$) between seasons, and significant differences between stations except for station-2 with station-3 (Table 1).

The degree of organic matter contamination, the destruction of organic compounds, and the level of self-purification of the water can all be determined using the DO measurement. (McCabe *et al.*, 2021).

The concentration of DO raising in winter may be due to the increased aeration because of rainfall, in addition to the higher water flow during winter and decrease in temperature cases increase the oxygen solubility (Ismail and Abed, 2013). Then the decrease in DO in summer may be a result of an increase in temperature, biological activity, organism respiration, and the rate at which organic matter is decomposing (Liu *et al*.,2020). Results of DO content are within the limits of Iraqi, WHO, and Iraq standards for river water noted that the optimal value of DO was more than 5 mg/l.

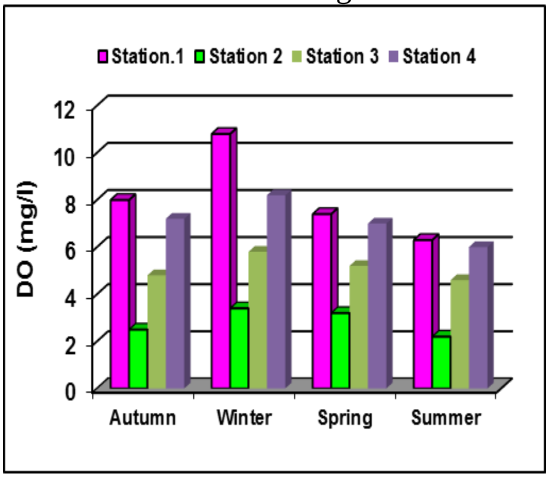

Fig. (5) Seasonal variation of Dissolved Oxygen in Tigers river during the study period.

Biological Oxygen Demand (BOD_5)

The current study has shown that the highest mean value of BOD was 7.6 ± 0.2 mg/l in the winter season at station-2, and the lowest BOD mean value was 1.8± 0.1 in the summer season at station-1, as shown in Fig. 6.

Statistical results refer to a significant difference ($P \leq 0.05$) between seasons but no significant differences between stations. Table 1.

The BOD results from station 2 were higher than other stations because of the high discharge of sewage enriched with organic matter. The increase of BOD in autumn and winter is possibly a result of the organic materials which enter in large amounts with rainfall and increase with the presence of high pollution levels of discharged sewage, fertilizers, and other nutrients. Oxygen is used by aquatic organisms to live, and used in the decomposition process (Wahab *et al*., 2019).

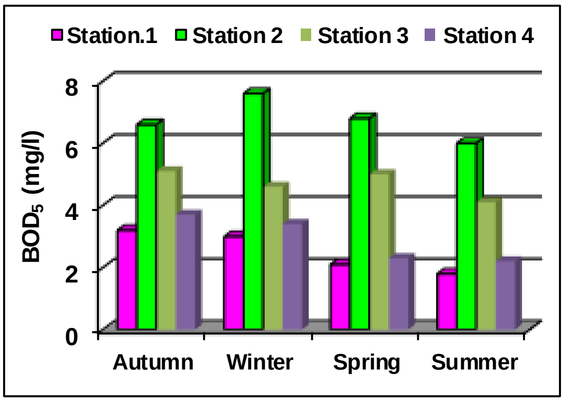

Fig. (6) Seasonal variation of BOD_5 in Tigris river during the study period.

Total Organic Carbon (TOC)

Results show the greatest mean value in the summer with 50.9 ± 4.2 mg/l in station 2, and the lowest value in autumn with 8.4 ± 0.5 mg/l in station 1(Fig. 7. In addition, the statistical analysis showed significant differences at ($P \leq 0.05$) among seasons, and stations. Table 1.

TOC reacts with chlorine during disinfection processes and leads to the formation of THMs (Sriboonnak *et al*., 2021). This study's results show an increase in TOC with increasing temperatures. The presence of TOC gives evidence for the presence of organic material in the water and thus directly impacts the values of DPBs that go up its altitude. The high summer heat and precipitation in the wintertime Tigris basin in 2022 may have contributed to the variations in TOC levels in the Tigris river.

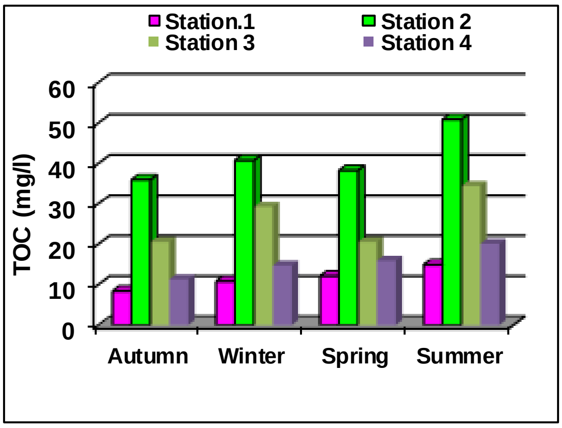

Fig. (7) Seasonal variation of Total Organic Carbon (TOC) in Tigris river during the study period.

Total Trihalomethanes (TTHMs):

The obtained results showed that the TTHMs concentration levels had the highest mean value in summer with 87.6±10.0 mg/l in station 2, and the lowest value was nil seen at station 1 and station 4 during the all study time, as shown Fig. 8. Furthermore, the statistical analysis revealed significant differences at *(*$P \leq 0.05$) among seasons, and significant differences between stations except for station-1 with station-4. Table 1. There are no existing THMS compounds in station-1, because, no discharge and no disinfection process so it's nil.

The THM compounds have a solubility of less than 1 mg/ml in water at 25°C and are relatively very volatile. (Bexfield *et al.*, 2022), so it is not found at station-4, these THMS compounds were reacted with other compounds present in water becoming more toxic, causing harm to aquatic organisms. Tigris river varies considerably in concentration because of the self-purification mechanism, good mixing, and larger water volume (Oleiwi and Al-Dabbas,2022).

The THMs levels in the summer season were higher than those of the Autumn and winter seasons at station-2; because raising the water temperature sped up the interaction between NOM and the additional chlorine, and the increased production of THMs as a result water quality was a mostly high level of TOC during the summer, and treatment plant operational factors including increasing chlorine dose (Zhang *et al.*, 2013).

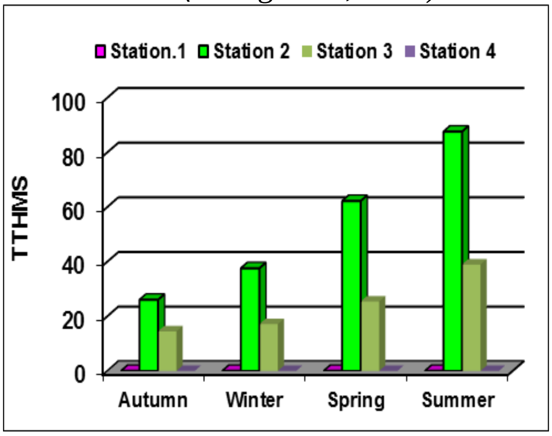

Fig.(8) Seasonal variation of Total Trihalomethanes (TTHMs) in Tigris river during the study period.

Also, the study results have indicated that chloroform (CF) was the major constituent of the TTHMs content and ranged between 10.25 and 31.2 ppm in Autumn and Summer, respectively where it represents 36.9% of TTHMs. The general trend of TTHMs components distribution followed the order: Chloroform (36.9%) > bromoform (28.1 %)> dibromochloromethane (24.69%) >bromodichloromethane (10.36 %) (Fig. 9).

Table (1) In Baghdad, the Tigris River's Mean ±SD THM and Physicochemical Parameters for the Years 2021–2022 for Tigris river's in Baghdad city.

Parameter	Season	Station1	Station2	Station3	Station4	LSD value
Turbidity (NTU)	Autumn	12±1.0	88±2.0	65±2.0	35±2.0	37.65*
	Winter	18±1.2	165±4.0	85±2.8	40±2.5	52.84*
	Spring	16±1.0	105±2.0	56.2±2.0	32.3±2.0	39.77*
	Summer	9.4±0.9	90±2.0	45.5±2.0	20.6±1.4	34.15*
LSD value		10.73 NS	42.17*	35.94*	22.53 NS	---
Electrical Conductivity	Autumn	860±8.0	1673±14.0	1066±14.0	915±9.0	136.77*
	Winter	650±8.4	1256±13.0	995±10.0	760±8.0	122.95*
	Spring	610±8.2	990±10.0	810±9.0	735±8.3	128.74*
	Summer	913±9.0	1809±15.0	1115±12.0	980±8.6	172.03*
LSD value		162.08*	215.56*	174.92*	118.43*	---
Total Dissolved Solid	Autumn	484±10.5	990±15.2	685±9.0	500±10.2	171.20*
	Winter	501±11.3	1060±20.5	730±14.4	564±14.5	166.42*
	Spring	450±10.4	890±15.6	610±10.2	470±13.8	152.37*
	Summer	556±14.9	1182±20.7	985±10.0	620±15.0	184.13*
LSD value		94.36 NS	194.52*	164.03*	124.63*	---
Dissolved Oxygen	Autumn	8±0.5	2.5±0.1	4.8±0.7	7.2±0.2	2.75*
	Winter	10.8±0.5	3.4±0.2	5.8±0.6	8.2±0.3	3.01*
	Spring	7.4±0.5	3.2±0.2	5.2±0.2	7±0.2	2.84*
	Summer	6.3±0.4	2.2±0.1	4.6±0.1	6±0.1	2.49*
LSD value		2.56*	1.45 NS	1.62NS	1.94*	---
Biological Oxygen Demand	Autumn	3.2±0.1	6.6±0.1	5.1±0.1	3.7±0.1	2.37*
	Winter	3±0.1	7.6±0.2	4.6±0.1	3.4±0.1	2.44*
	Spring	2.1±0.1	6.8±0.1	5±0.2	2.3±0.1	2.48*
	Summer	1.8±0.1	6±0.1	4.1±0.1	2.2±0.0	2.51*
LSD value		1.53NS	1.89NS	1.75NS	1.67NS	---

Total Organic Carbon	Autumn	8.4±0.5	36±2.7	20.5±2.3	11.3±1.0	7.42*
	Winter	10.8±1.2	40.8±3.8	29.2±2.9	14.7±1.5	7.05*
	Spring	12.1±2.3	38.3±2.9	20.5±2.04	15.9±1.9	6.57*
	Summer	14.9±1.9	50.9±4.2	34.5±3.7	20.1±2.0	8.03*
		5.49*	7.33*	6.13*	6.08*	---
Total Trihalomethanes	Autumn	0±0.0	26.05±3.0	14.47±2.7	0±0.0	4.88*
	Winter	0±0.0	37.58±3.0	17.12±3.2	0±0.0	5.71*
	Spring	0±0.0	62.2±8.0	25.4±3.4	0±0.0	6.24*
LSD value	Summer	0±0.0	87.6±10.0	38.93±2.0	0±0.0	7.03*
		0.00NS	7.61*	6.35*	0.00NS	---

* (P≤0.05), NS: Non-Significant.

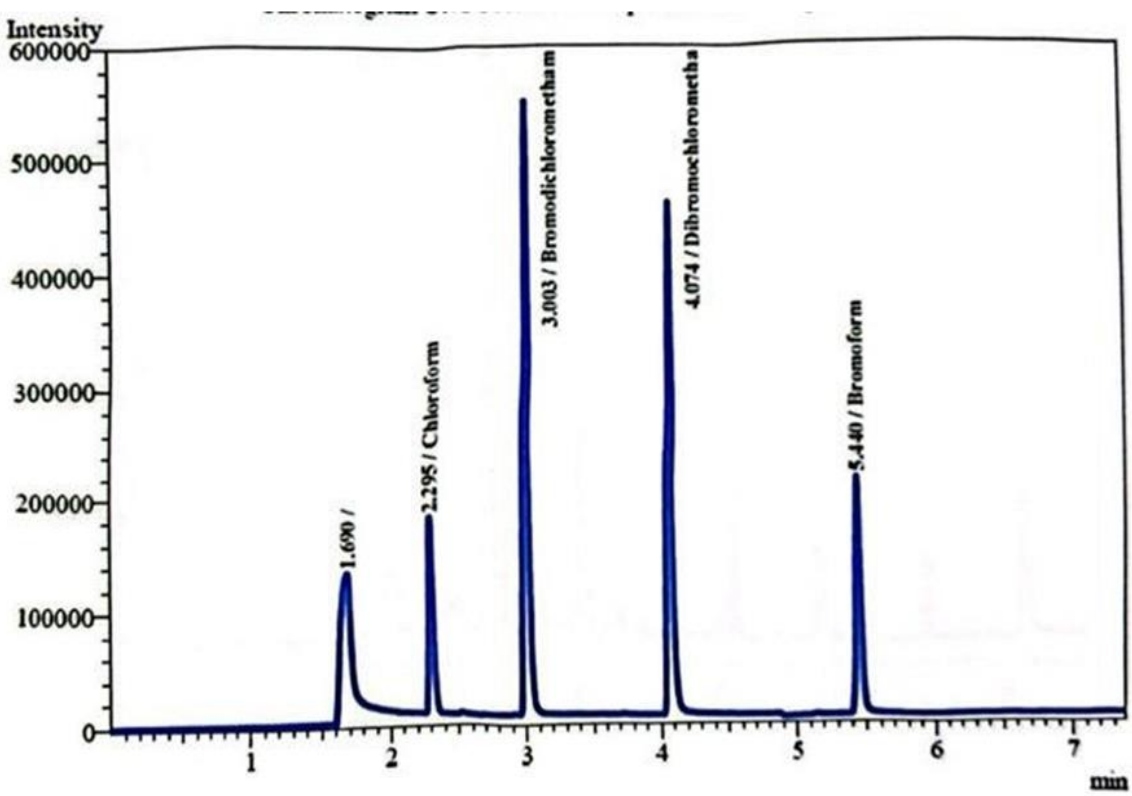

Fig (9) Total trihalomethanes (TTHMs) were determined measured Gas chromatography (GC).

Conclusion

The findings showed that the majority of the water parameters exceeded WHO and Iraqi criteria for the river. The wastewater of Medical City hospitals in Baghdad affects the characteristics of Tigris River water.

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