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MONITORING OF WATER QUALITY AND TRIHALOMETHANES CONCENTRATIONS IN SOME DRINKING WATER PLANTS

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Abstract
Chlorination is commonly used to inactivate or control microbial populations in the treated water, Disinfection by products are formed like trihalomethanes (THMs) when the chlorine react with organic matter in the water, This studies conducted annually to estimation the THMs and monitoring of water quality in river water during 2019-2020 for eight months. Water samples were collected from water purification plant (Al-Hashimiyah union project), The total concentration of THMs ranged between (11.6 – 42.2 µg/l) in the water purification plants. THM levels increased during the summer when recorded highest values on July and August with a comparison to the lowest values ding winter months (December and January). as well as results physical and chemical tests for the station during the study period. Air and water temperature was ranged of (12-49 C°), and (13-32 ° C), Turbidity (3- 83.6 NTU), PH (7.4 – 9.8), Total Dissolved Solids (540-1121 mg / L), E.C (813-1299 µ g / cm) and TSS (2-42 mg / L) TH (CaCO3) (160-390)mg / l dissolved oxygen It is (5-14) mg /l , free residual chloride (ND – 4.0 mg / l) , total al-kalinity (140-260) mg / l, phosphate (PO4) (0.1 – 0.5) mg /l, bromide (Br) (0.5 -0.1 mg /l).

Keywords: Trihalomethanes (THMs), Disinfection by-products , drinking water plants.

Introduction

The Water is an essential component of the food chain, and its quality is essential for human consumption drinking water is water that free of chemicals that are harmful to human health and microorganisms that cause disease. A variety of disinfection methods are used around the world for treatment, some of which are more common than others, such as chlorine , ultraviolet light, and ozone .{1}.
The most frequent technique is chlorination, which is extremely efficient, simple, and low-cost. Water disinfection with chlorine enhances sanitary quality by preventing illnesses including dysentery , diarrhea , cholera , typhoid fever and hepatitis A {2}.
The residual chloride in the water system can protect water against microbiological contamination. When chlorine is applied to drinking water sources, microorganisms such as bacteria, viruses, and protozoa can reacts with Natural organic matter (NOM) or aquatic biota excretion to generate chlorination disinfect by products (DBPs) such Trihalomethan (THMs){3}.

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The main groups of DBPs is THMs which included four compound are chloroform, bromodichloromethane, Dibromochloromethan and bromoform, In disinfected water by chlorine the total of THMs concentration depends on the disinfectant's amount added for the killing of pathogens and physicochemical properties of water as contact time, pH, concentration organic matter TOC and temperature.{4}.

THMs are mainly confined into four prevalent groups of chlorinated and brominated THMs are Trichloromethane (TCM), Bromodichloromethane (BDCM), Dibromochloromethane (DBCM), and Tribromomethane (TBM), this compounds classified in Group 2B as a possibly carcinogenic in humans as well as based on limited indications of carcinogenicite in humans but suitable evidenced to carcinogenicity in experimental animal {5}.

Table (1): The health effects and cancer group of 4THMs (RAIS, 2009)

DBPs	Compounds	Cancer group	Potential Health Effects
THMs	Chloroform	B1: probable human carcinogen	Cancer , liver, reproductive effects.
	Dibromochloromethane	B2: probable human carcinogen	Nervous, kidney , liver and reproductive effects.
	Bromodichloromethane	C = possible human carcinogen.	Cancer, kidney and reproductive effects.
	Bromo form	B2 = probable human carcinogen	nervous system, Cancer , liver and kidney effects.

The properties of the treat drinking water, such pH, water temperature , chlorine concentration, bromide ion , and natural organic content, all influence the disinfection by-product. As well as the distribution system's features, such as the amount of time the treated water is held before being used and the presence of erosion materials on pipe walls. {6}.

Due to the lack of studies in this region , the present study were carried out to monitoring to water quality and measuring the concentration of TTHMs in the water purification plants in Babylon and determined of individual of THMs as well as to increase understanding of the effects of THM on public health.{7}.

MATERIALS AND METHODS

Description of study area and sampling .1

Study area located in central Iraq and in the western part of the Euphrates, There are stations within the study area, which is the Al-Hashimiyah Unified Project, this station located in south of Babylon on the Shatt Al-Hilla, and one of its main branches

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of the Euphrates River in Babylone province, The capacity of the plant is 50,000 M^3/day. This plant is located in an agricultural area north of the Al-Qasim city {8}. The samples was collection from four points included river water (St.1), inside plant; sedimentation tanks(St.2), Chlorination tanks(St.3), and distribution system (St.4). Its collected periodically during November 2019 through December 2020 for eight months. As well as avoid air bubbles and lost THM, a 500 ml sample was collected in clean, fully filled glass containers and sodium thio-sulfate (10 mg \ 10 mL) also added a chlorinating agent , all sealed TFE-lined glasses bottles are placed in a cooler box , stored at 4 °C until the analysis was done{9}.

Water quality parameters .2

Water and air temperature, pH, EC, turbidity, TDS, TSS, free residual chlorine, total hardness, phosphate (PO_4), total alkalinity, nitrites (NO_2), nitrates (NO_3), chloride, sulfates, bromides, TOC measure in the laboratory according to specific procedure, described in APHA standard method , water samples were taken from four sites of Al-Hashimiyah unified project periodically during eight months. {10}.

Gas Chromatography Analysis: .3

THMs samples were examined using Gas Chromatography in the Environmental and Water Directorate's laboratories. The operating condition was set (flow rate 30 ml /min, electron capture detector (ECD) , temperature (50–150 °C). THMs were determined using an electron capture detector and a Gas chromatography model (DANI GC 1000 , Dani Instrument SPA, Italy) (GC-ECD). A four THM standard ampoule 1 ml mixture 2000g/L leach THM in methanol from Sigma-Aldrich was used to create the calibration graph, The THMs (Chloroform(CF) , BDCM , DBCM , and Bromoform (BF) that concentrations was calculated use standard Methods , THMs is calculated using the following equation, The results were expressed as µg/l. {11}.

Result and Discussion:

1- Water quality parameters:

The results of current study showed that physical and chemical tests for the All stations during the study period. Air and water temperature was ranged of (12-49 C°), and (13-32 ° C), Turbidity (3- 83.6 NTU), PH (7.4 – 9.8), Total Dissolved Solids (540-1121 mg / L), E.C (813-1299 µs / cm) and TSS (2-42 mg / L) TH ($CaCO_3$) (160-390)mg / l dissolved oxygen It is (5-14) mg /l, free residual chlorine (ND – 4.0), total al-kalinity (140-260) mg / l, phosphate (PO_4) (0.1 – 0.5) mg \l , bromide (Br) (0.5 - 0.1) , variance was assessed in the quality parameters as follows shown in Table (3), analysis of variance showed that air temp, Water temp.°C Hydrogen ion (Ph), E.C and TDS mg/l are no significant difference among sites ,($P > 0.05$) there was significant difference in four seasons ($p < 0.05$).

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Table n. (1) : Means and standard deviation of some physicochemical properties to water sample from four sites of Al-Hashemyah (unified Project) plant during the study period.

Properties	Means ± SD				LSD
	St 1	St 2	St 3	St 4	
Air temp. °C	36.5 ±2.48	36.5 ±2.48	36.5 ±2.48	36.2 ±2.65	NS
Water temp.°C	44 ±2.76	44 ±2.76	44 ±2.76	43.7 ±3.06	NS
Hydrogen ion (PH)	8.2 ±0.94	7.7 ±69	7.8 ±0.75	7.8 ±0.75	NS
E.C. µs/cm	1269 ±117.58	1039 ±87.19	1054 ±102.51	1069 ±91.23	NS
Turbidity (NTU)	30 .2 ±2.55	20.4 ±1.62	9.2 ±0.87	4.4 ±0.36	5.62 *
TDS mg/l	647 ±74.01	609.5 ±55.27	673.5 ±41.09	650 ±47.20	NS
TSS mg/l	29 ±1.83	12 ±0.92	7 ±0.55	6.5 ±0.39	7.21 *
TH ($CaCO_3$) mg/l	282 ±37.55	260 ±29.04	247.5 ± 36.32	235 ±24.94	46.07 *
Dissolved Oxygen	11.5 ±0.63	9 ±1.06	8.8 ±0.75	7.5 ±62	2.39 *
(BOD_5) mg/l	7.5 ±0.58	7 ±0.61	8.5 ±0.97	9 ±1.15	1.65 *
Chlorine mg/l	0 ±0.00	0 ±0.00	1.7 ±0.07	1.35 ±0.09	0.706 *
Nitrite (NO_2) mg/l	2.6 ±0.09	2.9 ±0.12	2.2 ±0.=12	2.1 ±0.08	0.574 *
Nitrate (NO_3) mg/l	43 ±3.69	25 ±1.83	29 ±2.33	20 .5 ±1.72	7.29 *
Sulfate (SO_4) m	320 ±35.22	321.5 ±27.19	341 ±30.66	333.5 ±28.93	NS
Bromide (Br)	0.3 ± 0.08	0.2 ± 0.06	0.2 ± 0.06	0.2 ± 0.05	NS
Total alkalinity mg\l	200 ±25.44	188.5 ±17.74	185 ±16.92	188 ±17.05	NS
Phosphate (PO_4) mg\ l	0.2 ± 0.06	0.3 ± 0.07	0.1 ± 0.0	0.1 ± 0.02	NS
Total Organic Carbon (TOC)	4.1 ±0.27	3.9 ±0.15	3.9 ±0.12	3.8 ±0.15	NS

Ns: is non-significant

Concentrations of THMs Compounds

For four seasons, total trihalomethanes concentrations (TTHM) were monitored in raw water samples, sedimentation tanks, chlorination tanks, and distribution networks. Table 2 summarizes the findings. TTHM levels are frequently elevated in treated water. When compared to untreated water. Table 2 shows the concentration kinds to TTHMs : CF, BDC, DBCM and BF, during the summer high amounts of TTHMs of 48.2 g/L were discovered in the distribution networks near Al-Hashimiyah

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Station, during the winter the low concentration (4 g / L) found in Distribution networks at the leading station.

The significant occurrence of THMs in the distribution networks near the Hashimiyah station could be owing to a long Residential period and high chlorine dosages used. The presence of TTHMs in water samples collected from the distribution The networks of the regime were below the Iraqi standard limit of 150 g/L. During the summer, however, a large number of tests surpassed the USEPA's maximum contamination threshold (80) ug/l.

Analysis variance of these results show significant differences ($p \leq 0.05$) among TTHMs concentrations in sites and seasons of water plant (Table 2) Also, significant differences have been between water plant in terms of before and after water treatment during four seasons . This attributed that the water detention time in service reservoirs and free chlorine contact time which were different from plant to another.

Organic matter content increased during the summer months owing to fast decomposition of plants. Rains also enhance the amount of organic matter in the soil by allowing it to seep into the watersheds.

The THMs in treated samples taken ranged from 4.5 to 48 g / l in the winter and summer, respectively, the main trends of THMs types was as follows: D BCM (9%) > B DCM (10%) > CF (42%) > BF (39 %), This studies describes the treat water produced by the water treatment plant, It did not fall within the limits of the World Health Organization but within the Iraqi standards with regard to water treatment plants.{13}.

Table (2) : value ± SD and LSD value of total trihalomethanes (TTHMs) and its compounds (CF, BDCM, DBCM, and BF) in water sampled from five sites of Al-Hashemyah water plant during four seasons.

Sample sites	Compounds	Winter	Spring	Summer	Autumn	LSD value
Raw water (River)	Chloroform (CF) µg/l	6.3	6.5	7.3	3.8	1.06 *
	Bromodichloromethane (BDCM) µg/l	0.4	0.9	1.8	0.9	1.44 *
	Dibromochloromethan (DBCM) µg/l	0.7	0.3	2.3	0.5	1.19 *
	Bromoform (BF) µg/l	13.4	20	22	9.4	0.882 *
	Total (TTHMs) µg/l	20.8	27.7	33.4	14.6	2.58 *
Sedimentation tank	Chloroform (CF) µg/l	2.1	4.3	6.5	9.7	0.805 *
	Bromodichloromethane (BDCM) µg/l	0.8	0.9	1	1.5	1.55 *
	Dibromochloromethan (DBCM) µg/l	1.1	1.1	1.9	1.2	1.07 *

	Bromoform (BF) µg/l	11.2	11.2	20.8	20.1	0.784 *
	Total (TTHMs) µg/l	15.2	17.5	30.2	32.1	2.92 *
Chlorination tank	Chloroform (CF) µg/l	15.7	15.7	14.7	9.6	3.06 *
	Bromodichloromethane (BDCM) µg/l	0.4	0.8	1.9	1	3.75 *
	Dibromochloromethan (DBCM) µg/l	0.7	1.5	2.5	1.3	3.69 *
	Bromoform (BF) µg/l	9.9	17.6	23.1	20.3	1.97 *
	Total (TTHMs) µg/l	12.9	35.6	42.2	32.2	7.21 *
Distribution pipes (network)	Chloroform (CF) µg/l	9.6	9.2	9.2	1.6	3.77 *
	Bromodichloromethane (BDCM) µg/l	2.7	0.6	1.5	0.3	5.61 *
	Dibromochloromethan (DBCM) µg/l	6.5	1.5	2	0.2	3.66 *
	Bromoform (BF) µg/l	ND	ND	12.9	2	1.42 *
	Total (TTHMs) µg/l	18.8	11.6	25.6	4.1	6.83 *
LSD value	---	4.37 *	5.06 *	7.81 *	6.24 *	---

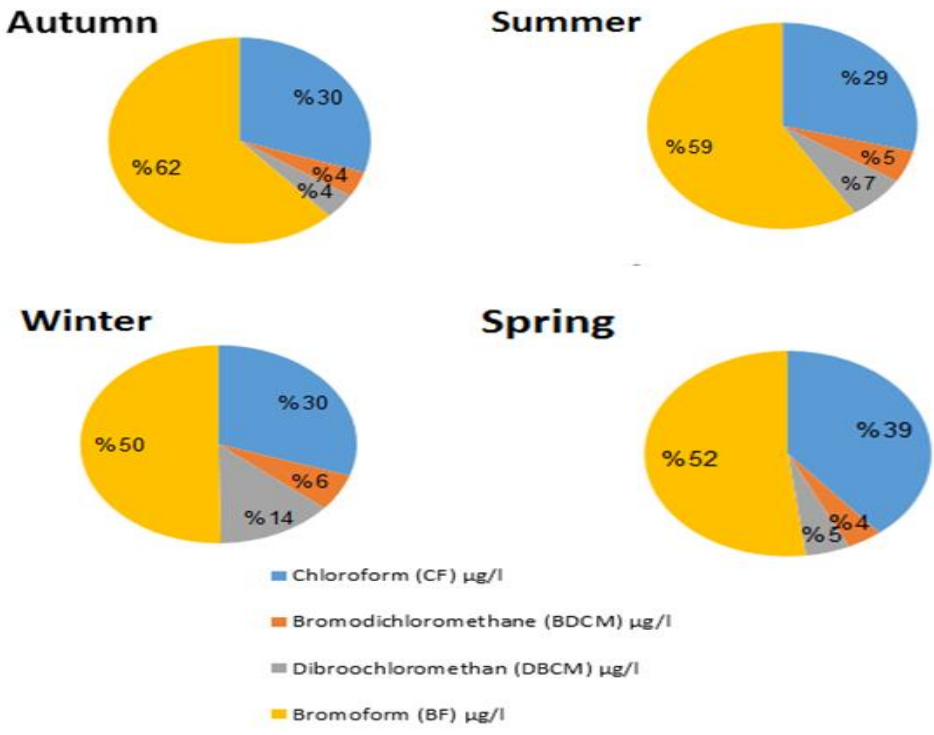

Fig. (1) : percentage of THMs component distribution in drinking water in Al-Hashimiyah Unified Project during th four seasons

Conclusions and Recommendation

The objective from this study estimated THMs concentrations to drinking water plant on sites at some areas of Babylon City\Iraq, this results showed of THMs, it's Water

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and Air temperature, pH, EC, Turbidity, TDS , TSS , Free residual chlorine, Total hardness, Phosphate (PO4), Total alkalinity, Nitrite (NO_2) , (BOD_5), Nitrate (NO_3) ,Chloride, Sulphate, Bromide, and TOC are recorded Monthly. {14}.

Trihalomethanes levels in drinking water are frequently linked to a variety of issues (temperature, organic matter, chlorine dose, distance of supply points). During the study period, the presence THMs into water purification facilities as well as locations between feeding station was within the permitted limits (150 g/liter) set by the Iraqi drinking water standard, The concentration of THMs in , water samples collection on one treatment plant in the south of Babil Governorate, in general, some concentrations exceeded the permissible limits recommended by the World Health Organization and Iraqi standard , The seasonal variation TTHMs concentration following : summer, > Autumn, > Spring > Winter .{15}.

So that must use a new technology to monitoring and reduction of the THMs level in filter units by addition suitable chlorine dosage, Reduction of Trihalomethan during purification via using aeration power or activate for decreasing of natural organic matter, The commitment of the station workers to add an appropriate amount of chlorine and raw water in the plant must be treated from plant, animals residues, mud and sediments before adding chlorine{16}.

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