Plant Archives Vol. 20, Supplement 2, 2020 pp. 3111-3117 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

MONTHLY CHANGES OF SOME PHYSICO-CHEMICAL PROPERTIES FOR TIGRIS RIVER WATER AND EVALUATION OF ITS CONTAMINATION BY SOME HEAVY METALS

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Abstract

To study monthly changes of some physiochemical characteristics of Tigris River water within boundaries of Baghdad city, confined to Rashidiya - Salman Pak and evaluation its chemical contamination with some heavy metals (Pb, Cd, Cu, Ni) for period from May to December, 2019. Eight sites were chosen as Rashidiya, Medical City, Beiruti, before Dora, after Dora, Tuwaitha and finally Salman Pak. Results showed that electrical conductivity (EC) values were between 0.66-1.69 dSm^{-1}, highest value was at site of Medical City in May. Concentrations of TDS, ranged between 190.33-893.89 mgL^{-1}, as highest value reached at Medical City site in May, results also showed that concentration of Lead in water ranged between 0.01-1.23 mgL^{-1}, highest concentration was in a site after Dora in July. Highest pH value was in June 8.23 at Medical City and before Dora sites. Highest value in turbidity was in December 23.06 NTU at the site of before-meeting Diyala River with Tigris River. Highest Calcium concentration for different study sites was in September 179 mgL^{-1} at Beiruti site. Highest Magnesium concentration in September was 38 mgL^{-1} at Medical City site, whereas, in May, Sodium reached 101 mgL^{-1} at sites of after Diyala River meets Tigris River (Tuwitha) and Salman Pak. Lead concentration ranged between 1.23 - 0.01 mgL^{-1}, highest concentration was at Medical City site in July. Cadmium ranged between 0.01-0.18 mgL^{-1}, the highest concentration was at Medical City site In September, both elements exceeded limits permitted by World Health Organization, while concentrations of Copper, Nickel, and Boron did not exceed internationally permitted limits.

Keywords: Tigris River, Contamination, Heavy Metals

Introduction

Environmental pollution is one of most important challenges facing inhabitants of globe at the present time. Environmental pollution is defined as changing basic elements of environment (soil, water and plant) to degree that leads to deterioration of its various characteristics as a result various human activities, rivers suffer in general from many environmental problems, foremost of which is environmental pollution and specific deterioration of the water resource, which negatively affects water and fish resources in rivers, as well as their effects on agricultural and economic activities dependent on them.

Tigris River suffers from escalation of pollution levels due to civil, industrial and agricultural activities. Heavy metals are most important pollutants present to environment at present (Za'lan *et al*., 2006) and their danger increases when they remain in soil or chemical changes are made upon them Then it leads to contamination of plants, fruits and vegetables that humans eat, which reflects on his health. Heavy metals pollution is one of forms of environmental pollution resulting from human, agricultural and industrial activities.

In recent years, scientists have paid attention to studying heavy metals, their environmental and health effects as well as setting determinants of upper and lower limits of their focus in environmental and water environment in particular (Naik *et al*., 2014). Higher concentrations of these elements in plants than the permissible limits endangers life of consumer. Increase in concentrations as a result of plant growth in soil contaminated with it for many reasons, including irrigation with water contaminated by waste of factories, factories, sewage and others.

Heavy metals such as Lead, Cadmium, Zinc, Nickel and Cobalt are among most dangerous pollutants in soil, water and air, which cause severe damage to humans, animals and plants (Li *et al*., 2011). Abdul-Kareem *et al*. (2011) studying levels of heavy metals in Tigris River in Baghdad city and determining possible dangers of river pollution, indicated that concentration of Cadmium ranged between 50-290 mgL^{-1} exceeding critical limits of international and Iraqi specifications for drinking water.

Al-Ubaidi (2014) showed that distribution of heavy metals in water of Tigris River in city of Baghdad was fluctuating, except for Lead, as its high concentrations reached an average of 0.359 mg L^{-1}, while Cadmium was 0.012-0.639 mg L^{-1} exceeding internationally permitted limits.

Abboud (2015), studying concentrations of heavy metals in selected sites on Tigris River (Al-Adhamiyah, Al-Shuhada and Al-Jadriya Bridge), indicated that concentration of Cadmium ranged between 0.01- 0.014 mgL^{-1} exceeding permissible limits of Iraqi determinants of river maintenance system No. 25 of 1967. Research aims to study monthly changes of some physiochemical characteristics of Tigris River water–Baghdad and evaluation its chemical contamination with some heavy metals (Pb, Cd, Cu, Ni).

Materials and Methods

Study area included Tigris River within boundaries of Baghdad city, starting from Rashidiya area, where Tigris River entered Baghdad city, down to Salman Pak region in south, exit area of Tigris River from Baghdad city, they are sites of Rashidiya, Medical City, Beirut, before Dora power station, after Dora power station, before Diyala River meets Tigris River, after Diyala River meets the Tigris and Salman Pak. Samples were collected from Tigris River for chemical, physical and biological analyzes monthly from May to December/2019 with three replications from eight sites on Tigris River.

Water samples were placed in plastic bottles with a capacity of one liter cleaned and prepared for this purpose made of polyethylene, after washing it well with distilled water then contaminated with river water several times, after that bottle was filled to nozzle and three drops of Toluene substance were added to prevent bacterial growth and kept in refrigerator until required analyzes were conducted , water temperature was measured field.

Water pH measured by pH-meter, electrical conductivity (EC) and total dissolved solids (TDS) were measured by EC-meter, turbidity was estimated using a Turbidity-meter, Carbonate and Bicarbonate were estimated by titration with dilute sulfuric acid (0.01 N) using orange methyl index (Richard, 1954), sulfate was estimated by Spectrophotometer using barium chloride (Black *et al*., 1965), Chlorides were estimated by titration method with silver nitrate (0.01N) using potassium Chromate guide (Black *et al.*, 1965). Boron estimated after color development using Carmine dye and measured by spectrophotometer (APHA, 2012).

Potassium and Sodium were estimated by Flame-photometer (APHA, 2012). Calcium and Magnesium ions were estimated by titration with EDTA-Na2 (Richards, 1954), Chemical Oxygen Demand(COD) estimated by dichromate method using Spectrophotometer (APHA, 2012), TOC estimated according to APHA (1998), Sodium adsorption ratio (SAR) calculated according to formula given in Richards (1954), SAR Adjusted ratio calculated according to equation in Ayers and Westcot (1976), Exchangeable Sodium Percentage (ESP) calculated from equation in Richards (1954), Residual Sodium carbonate calculated according to the equation in APHA (2005), total heavy metals (Pb, Cd, Ni, and Co) were measured by Atomic Absorption Spectrophotometry (AAS) (APHA,2012).

Results and Discussion

Results of different physical, chemical and biological analyzes in tables 1 and 2 indicate presence of changes in physical, chemical and biological characteristics of Tigris River water, concentrations of pollutants were clearly related to time period depending on amount of absolute that is discharged into Tigris River and water increase and decrease, in addition to effects of climate, represented by temperature, evaporation, and amount of rainfall in basin of Tigris River.

Physical and chemical properties

Results of table 1 showed a variation in temperatures of different study sites, as the highest temperature of water was in July and August at 29 C° in sites of after Dora and before Diyala River meets Tigris River, lowest temperature of water was in December 12 C° in all sites. High temperature of water in two sites above may be due to discharge of water from electric power station in Dora and a power station in south of Baghdad to river, this water has temperatures that exceed water temperature 1-2 C°, these results are consistent with Muften *et al*. (2019), as they explained that temperature of water at site near power station south of Baghdad is highest temperature for river's water, and that, due to impact of site, it reached 38.3 C° in September.

pH ranged between 7.16 in before Dora site at May to 8.23 in both Medical City and before Dora sites at June and May. Most of water in studied sites tends to light alkalinity. High pH in medical city site may be due to discharge of divorcees of medical city hospital without treatment, harmony. These results are consistent with Muhammad *et al*. (2017), who showed that wastewater of hospitals that are released to Tigris River tends to alkalinity level, which is reflected in pH value of River water.

Highest value of turbidity was in December 23.06 NTU in site of before Diyala River meets Tigris River, lowest value in May 6.40 NTU at Beiruti site, this increasing in turbidity may be due to nature of River bed and its containment of high amounts of clay deposits, as well as sculpting and erosion processes because of increase in river's speed in this region, presence of twists and its industrial units, including addition waste of various human activities in Baghdad to river, these results are consistent with Muften *et al*. (2019), who showed that concentration of turbidity at a site before Diyala River meets Tigris River were highest at 68.6 NTU. Electrical conductivity (EC) were highest value in May of 1.69 dSm^{-1} in medical city site, lowest value of electrical conductivity in January 0.66 dSm^{-1} in Al-Rashidiya and Beirut sites, increasing in values of electrical conductivity in medical city site at May may be due to increase in divorcees of River Tigris compared to other months, in addition to high temperatures in this month, which leads to increased water evaporation and increased concentrations of dissolved substances in it, results are consistent with Al-Ani *et al*. (2019), who showed that electrical conductivity values for Tigris River ranged between 0.58-1.10 dSm^{-1}. Highest concentration of TDS in May reached 893.89 mgL^{-1} in Medical City site, lowest concentration in December was 190.33 mgL^{-1} In Rashidiya site.

Increase in amount of dissolved solids in Medicine city may be due to increased discharge of releases to river compared to other months, as water of Tigris River affected by wastes of Medical city site loaded with salts, dissolved materials and other pollutants, this rise in the quantity of dissolved solids clearly contributed to changes in water quality of Tigris River in this site, results are consistent with Al-Ani *et al*. (2019), who showed that amount of dissolved solids of Tigris River water ranged between 362-711 mgL^{-1}.

Total hardness ranged between highest concentration at September was 589.44 mgL^{-1} in Beiruti site, lowest concentration in December was 217.23 mgL^{-1} in site of before Dora. Increase in total hardness concentration in river water during summer months may be due to low level of river water and increase in temperature, which leads to high rates of evaporation and increase in total hardness in river water, results are consistent with Falih and Rashid (2016) who indicated that values of total hardness were higher in October 2010 amounted to 310-500 mgL^{-1} due to low level of Tigris River within Baghdad.

Table 1 : Physical, chemical and biological characteristics of the study area waters for the period of May-December / 2019

Location	Months	EC	pH	TDS	T.H	SAR	Adj SAR	Tur	TOC	COD	T	ESP	RSC
		dS cm^{-1}	-	mgL^{-1}	mgL^{-1}			NTU	mgL^{-1}		c°		
Rashidiya	May	1.03	7.60	539.33	327.33	1.46	3.00	12.30	25.33	99.33	20	0.51	-3.60
	June	1.14	8.03	596.33	281.66	1.33	3.07	9.90	25.33	104.33	24	0.63	-4.03
	July	0.98	7.76	515.33	305.53	1.82	3.74	14.83	22.33	90.33	24	1.14	-3.00
	August	1.00	8.00	521.00	319.33	1.85	4.10	15.50	22.00	91.00	25	1.39	-2.36
	September	1.08	7.72	804.66	338.33	1.66	3.54	17.43	20.33	86.66	21	1.01	-5.44
	October	0.90	7.52	673.33	305.66	1.72	3.93	17.10	19.33	83.33	19	1.00	-4.98
	November	0.73	7.50	550.33	284.67	1.43	2.96	17.53	17.00	77.33	14	0.42	-4.57
	December	0.66	7.40	190.33	255.00	1.37	2.50	17.90	15.33	72.33	12	0.21	-4.04
Medical City	May	1.14	7.63	604.33	336.32	1.24	3.23	16.20	54.66	179.66	20	0.57	-4.04
	June	1.16	8.23	613.33	311.66	1.70	4.27	15.16	40.66	149.33	24	1.25	-3.52
	July	0.97	8.00	511.33	289.66	1.35	3.29	17.06	45.33	156.66	24	0.73	-3.61
	August	1.05	8.06	557.33	294.96	1.54	3.82	15.76	45.33	157.33	25	1.02	-3.23
	September	1.69	8.23	893.89	526.66	1.19	3.38	18.73	31.66	107.00	21	0.51	-6.72
	October	1.28	8.11	678.00	422.33	0.78	1.97	19.66	24.66	100.00	19	-0.10	-5.85
	November	0.96	8.00	512.00	329.00	0.79	1.98	21.83	22.66	93.00	14	-0.09	-4.33
	December	0.85	7.90	451.66	279.36	0.75	1.82	22.50	22.00	86.66	12	-0.15	-3.50
Beiruti	May	0.93	7.83	494.33	301.54	0.84	2.05	6.4	32.66	110.33	20	-0.02	-3.32
	June	1.01	8.16	534.00	294.34	1.16	2.87	6.56	24.66	101.33	24	0.46	-3.18
	July	0.97	7.83	515.66	276.33	1.45	3.33	14.36	24.33	85.66	24	0.89	-2.78
	August	0.86	8.06	507.66	259.06	1.58	3.82	11.86	33.00	91.33	25	1.09	-2.30
	September	1.20	7.71	893.00	589.44	1.19	3.58	15.46	24.66	79.66	21	0.50	-8.44
	October	0.85	7.40	629.66	395.10	1.02	2.71	15.66	19.33	75.00	19	0.25	-5.31
	November	0.72	7.37	537.66	352.41	0.91	2.38	16.23	17.33	70.66	14	0.09	-4.92
	December	0.66	7.23	494.33	317.82	0.87	2.18	16.66	17.00	69.33	12	0.02	-4.37
before Dora	May	0.96	7.16	497.00	289.00	0.88	2.16	14.46	29.66	104.66	20	0.04	-3.10
	June	1.00	8.23	513.33	302.96	0.90	2.21	12.63	27.00	101.00	24	0.06	-3.71
	July	0.96	8.00	492.33	290.33	1.42	3.93	20.26	21.33	90.00	24	0.85	-2.76
	August	0.96	8.00	496.33	246.66	1.55	3.78	12.90	29.00	110.66	25	1.03	-2.36
	September	1.13	7.75	581.00	324.66	1.34	3.40	16.13	26.66	90.33	21	0.72	-3.15
	October	0.98	7.35	504.66	276.62	1.19	2.99	16.86	20.00	70.33	19	0.50	-3.09
	November	0.84	7.33	432.33	234.00	1.16	2.57	17.23	17.66	66.66	14	0.46	-2.55
	December	0.77	7.33	396.33	217.23	0.85	2.15	17.63	18.33	65.00	12	-0.006	-2.32

Table 2 : Concentrations of cations , anions and heavy metals of the waters of the study area for the period of May-December / 2019.

Location	Months	EC	pH	TDS	T.H	SAR	Adj ASR	Tur	TOC	COD	T	ESP	RSC
		dS cm-1		mgL^{-1}	mgL^{-1}			NTU	mgL^{-1}		c°		
After Dora	May	1.20	7.63	628.33	355.00	1.42	3.85	16.26	24.33	98.33	26	0.84	-4.41
	June	1.15	8.00	603.00	309.89	1.61	4.11	15.36	27.00	100.3	29	1.13	-3.51
	July	1.09	7.76	571.66	304.00	1.49	3.82	12.10	32.66	94.66	29	0.94	-3.92
	August	1.13	7.96	593.00	315.42	1.51	3.72	12.90	29.66	87.00	29	0.98	-3.98
	September	1.44	8.05	751.66	411.00	1.38	3.65	17.80	26.33	90.33	26	0.78	-4.53
	October	1.21	8.03	633.33	391.66	0.91	2.21	17.73	22.33	81.00	24	0.09	-4.79
	November	1.05	7.80	548.00	332.33	0.92	2.24	18.20	20.33	79.00	17	0.10	-4.08
	December	0.95	7.65	496.00	298.25	0.86	2.05	18.86	19.00	75.00	14	0.01	-3.56
before the Diyala River meets the Tigris River	May	1.19	7.66	704.00	424.91	1.30	3.04	17.13	38.66	141.3	24	0.66	-5.71
	June	1.06	8.00	627.00	311.50	1.83	4.69	17.20	37.00	143.6	28	1.46	-3.47
	July	0.97	7.63	571.66	258.66	1.54	3.88	15.76	34.00	113.6	29	1.02	-3.72
	August	1.00	7.73	593.00	301.24	1.50	3.88	13.83	33.00	103.3	29	0.96	-3.69
	September	1.27	8.08	751.66	394.31	1.14	3.31	21.66	30.33	100.3	26	0.42	-4.81
	October	1.13	8.01	668.66	402.27	1.06	2.74	22.13	27.33	96.33	24	0.31	-4.82
	November	0.88	7.89	522.33	299.33	1.28	2.63	22.76	23.33	92.33	17	0.63	-3.44
	December	0.82	7.83	487.00	273.69	1.00	2.29	23.06	22.00	87.33	14	0.21	-3.10
after the Diyala River meets the Tigris River	May	1.59	7.83	839.00	445.33	2.08	5.49	17.96	43.33	161.3	20	1.82	25
	June	1.36	8.10	718.33	355.61	2.02	5.17	18.16	43.33	161.0	24	1.73	55.33
	July	1.32	8.03	699.33	332.97	2.17	5.51	19.23	41.33	154.0	24	1.96	32
	August	1.29	8.03	683.00	330.54	2.28	5.46	20.06	40.66	150.3	25	2.13	38.33

	September	1.39	8.21	732.00	438.66	1.14	2.84	20.66	34.66	140.3	21	0.42	45.33
	October	1.35	8.16	713.00	428.20	1.08	2.76	21.66	29.33	121.3	19	0.33	63.66
	November	1.15	8.06	609.00	357.00	1.08	2.80	21.76	27.33	117.6	14	0.33	68
	December	1.04	8.00	550.33	320.00	0.97	2.42	22.63	25.00	109.0	12	0.18	71
Salman Pak	May	1.00	7.83	591.00	327.51	1.46	3.55	12.30	25.33	99.33	20	0.91	-4.04
	June	0.88	8.10	521.66	281.49	1.33	3.42	9.90	25.33	104.33	24	0.71	-3.10
	July	0.99	8.03	584.00	305.53	1.82	4.63	14.83	22.33	90.33	24	1.44	-4.03
	August	1.02	8.03	604.00	319.29	1.85	4.62	15.50	22.00	91.00	25	1.49	-4.22
	September	1.13	8.26	669.30	338.47	1.66	4.24	17.43	20.33	86.66	21	1.21	-3.39
	October	1.02	8.16	605.00	305.36	1.72	4.28	17.10	19.33	83.33	19	1.29	-3.35
	November	0.89	7.30	526.00	285.00	1.43	3.59	17.53	17.00	77.33	14	0.85	-3.32
	December	0.80	7.33	473.33	253.00	1.37	3.13	17.90	15.33	72.33	12	0.77	-2.82
LSD 0.05		0.014	0.03	3.93	2.834	0.04	0.974	0.322	0.683	2.121	0.05	0.227	1.390

Location	Months	Na	K	Ca	Mg	Cl	HCO_3	CO_3	SO_4	Pb	Cd	Ni	Cu	B
		mgL^{-1}												
Rash-idiya	May	48.6	1.53	63.6	36.3	70.6	157.33	1.80	161.	0.04	0.01	0.01	0,02	0.05
	June	54.3	1.45	92.0	26.00	76.3	164.66	2.00	179.	0.02	0.01	0.01	0.01	0.21
	July	60.3	0.70	66.3	22.6	72.6	132.33	1.70	158.	0.03	0.03	0.01	0.03	0.49
	August	65.6	0.76	64.6	22.33	78.3	165.00	1.23	122.	0.03	0.02	0.01	0.02	0.25
	September	76.0	1.34	124	36.00	201	229.33	0.66	135.	0.02	0.02	0.01	0.02	0.17
	October	68.6	0.77	108	26.33	197	160.33	NIL	111.	0.02	0.02	0.01	0.02	0.13
	November	47.6	0.39	91.6	25.33	154	129.33	NIL	99.3	0.02	0.02	0.01	0.01	0.10
	December	40.0	0.39	81.6	23.00	135	119.33	NIL	89.3	0.01	0.01	0.01	0.01	0.07
Medical City	May	52.6	1.95	92.3	25.66	80.6	164.33	0.66	185	0.10	0.02	0.01	0.04	0.20
	June	69.3	1.95	80.3	27.00	106	166.66	NIL	161.	0.04	0.02	0.01	0.17	0.71
	July	53.3	0.39	70.6	27.66	81.6	134.00	1.00	141.	0.05	0.04	0.01	0.05	0.57
	August	61.3	0.39	68.6	30.00	93.6	164.33	0.33	137.	0.04	0.04	0.02	0.08	0.23
	September	63.6	12.0	148.	38.00	97.4	235.00	0.33	297.	0.15	0.18	0.01	0.07	0.22
	October	37.3	10.8	129	24.33	57.1	159.33	0.33	259.	0.02	0.02	0.01	0.06	0.20
	November	34.6	0.39	90.3	24.33	51.8	134.33	0.33	181.	0.02	0.02	0.01	0.04	0.11
	December	27.6	0.29	79.3	18.66	42.3	123.00	NIL	159.	0.02	0.02	0.01	0.03	0.09
Beiruti	May	33.6	1.17	89.6	19.00	51.3	166.33	1.00	132.	0.01	0.02	0.01	0.01	0.04
	June	46.3	1.04	82.6	21.33	50.3	164.66	1.43	165.	0.03	0.01	0.01	0.09	0.46
	July	56.0	0.91	60.6	30.33	79.0	168.66	0.66	119.	0.03	0.01	0.01	0.08	0.60
	August	59.0	0.78	60.3	26.33	91.3	177.33	NIL	91.3	0.03	0.01	0.01	0.05	0.15
	September	67.3	0.78	179.	35.00	234.	209.66	0.33	166.	0.03	0.01	0.01	0.04	0.11
	October	47.3	0.78	96.6	37.33	154.	160.33	NIL	133.	0.02	0.02	0.01	0.03	0.09
	November	39.6	0.39	90.0	31.00	123.	131.66	NIL	121.	0.02	0.01	0.01	0.02	0.06
	December	36.0	0.32	81.0	28.00	117.	118.66	NIL	46.0	0.01	0.01	0.01	0.02	0.05
before Dora	May	35.0	1.15	71.0	27.33	52.8	165.33	1.00	142.	0.06	0.01	0.01	0.02	0.20
	June	36.3	1.04	84.0	22.66	54.8	144.00	1.00	168.	0.02	0.02	0.01	0.07	0.08
	July	57.3	0.39	54.6	30.33	86.5	152.33	NIL	109.	0.04	0.04	0.01	0.04	0.53
	August	56.3	0.39	55.6	26.33	85.0	157.33	1.73	111.	0.04	0.04	0.01	0.04	0.11
	September	54.6	0.78	75.0	29.66	82.5	187.00	NIL	150.	0.02	0.03	0.01	0.05	0.11
	October	46.0	0.78	70.0	25.66	69.4	154.33	1.00	138.	0.02	0.04	0.01	0.02	0.10
	November	39.6	0.40	59.3	21.00	59.3	132.00	NIL	118.	0.02	0.03	0.01	0.02	0.08
	December	34.6	0.31	55.0	19.33	51.6	123.66	0.33	110.	0.02	0.02	0.01	0.01	0.07

Location	Months	Na	K	Ca	Mg	Cl	HCO_3	CO_3	SO_4	Pb	Cd	Ni	Cu	B
		mgL^{-1}												
After Dora	May	62.0	0.91	90.6	31.33	93.6	165.66	0.04	182.2	1.03	0.04	0.01	0.01	0.06
	June	66.0	1.17	80.6	26.33	99.6	164.66	0.06	162.1	1.10	0.02	0.02	0.01	0.09
	July	60.0	0.65	88.3	20.33	90.6	132.33	0.02	177.4	1.23	0.03	0.03	0.02	0.64
	August	62.0	0.39	90.0	22.00	93.6	142.66	0.02	180.9	0.83	0.04	0.03	0.02	0.18
	September	65.0	0.65	107	34.66	98.1	227.66	0.02	216.4	0.33	0.02	0.06	0.02	0.26
	October	42.0	0.78	101.	34.00	63.4	187.66	0.02	203.0	1.00	0.03	0.05	0.02	0.21
	November	37.6	0.42	88.3	27.33	56.8	159.33	0.01	177.2	0	0.02	0.04	0.01	0.18
	December	32.6	0.39	79.3	24.33	49.3	149.33	0.01	158.6	0	0.02	0.03	0.01	0.15

before the Diyala River meets the Tigris River	May	56.0	1.17	119.	31.00	84.5	171.00	1.00	239.1	0.04	0.02	0.01	0.04	0.07
	June	75.0	1.17	79.6	27.33	113.	169.00	1.00	160.1	0.02	0.02	0.01	0.06	0.07
	July	61.0	0.78	86.0	19.00	92.1	131.00	1.00	172.8	0.03	0.03	0.01	0.02	0.68
	August	60.3	0.39	84.3	22.00	91.1	142.66	1.00	169.5	0.04	0.03	0.02	0.02	0.24
	September	52.3	0.78	105	31.66	79.0	188.66	0.66	212.3	0.03	0.04	0.02	0.03	0.22
	October	49.6	0.78	102	35.66	74.9	199.00	NIL	205.6	0.03	0.04	0.02	0.02	0.14
	November	41	0.39	79.6	24.00	61.8	154.66	NIL	160.2	0.02	0.03	0.01	0.02	0.12
	December	38.6	0.33	77.3	19.00	58.3	143.33	NIL	148.6	0.02	0.02	0.01	0.02	0.1
after the Diyala River meets the Tigris River	May	101	1.17	123.	32.66	152.	180.66	NIL	247.2	0.08	0.02	0.01	0.04	0.26
	June	88	1.04	95.6	28.33	132.	179.33	NIL	192.2	0.05	0.04	0.01	0.02	0.28
	July	91.6	0.68	98.6	21.00	136.	151.33	0.33	198.3	0.04	0.03	0.02	0.03	0.94
	August	90.3	0.39	91.6	24.66	136.	154.33	0.33	184.2	0.04	0.04	0.02	0.04	0.39
	September	53.6	0.52	120	33.33	81.0	198.33	1.00	242.5	0.04	0.06	0.03	0.04	0.38
	October	51.6	0.78	111	36.66	78.0	210.33	1.00	223.1	0.03	0.05	0.02	0.03	0.32
	November	47.3	0.47	89.3	31.33	71.4	188.66	NIL	179.2	0.02	0.04	0.02	0.02	0.26
	December	39	0.39	80.6	28.00	59.3	179.66	NIL	162.1	0.02	0.03	0.02	0.02	0.22
Salman Pak	May	101	1.17	123	32.66	152.	180.66	NIL	247.2	0.08	0.02	0.01	0.04	0.26
	June	59.0	1.17	91.0	24.33	92.6	154.00	0.66	165.1	0.04	0.01	0.01	0.02	0.05
	July	52.0	1.17	75.3	22.66	78.5	155.00	0.66	135.6	0.02	0.01	0.01	0.01	0.21
	August	73.6	0.39	89.3	20.00	111.	127.00	1.00	160.8	0.03	0.03	0.01	0.03	0.49
	September	76.6	0.39	91.0	22.33	115.	132.33	1.00	163.8	0.03	0.02	0.01	0.02	0.25
	October	71.0	0.78	91.0	27.00	107.	207.33	0.66	163.3	0.02	0.02	0.01	0.02	0.17
	November	69.6	0.78	84.3	23.00	105.	168.66	0.66	151.8	0.02	0.02	0.01	0.02	0.13
	December	55.6	0.49	77.6	22.00	84.0	145.33	0.33	139.3	0.02	0.02	0.01	0.01	0.1
LSD 0.05		1.135	0.200	0.931	0.529	1.55	1.757	0.204	4.497	0.001	0.001	0.001	0.001	0.011

Concentration of soluble cations

Calcium concentrations during study period for different sites (table 2) ranged from 54.6 mgL^{-1} at July in site of before Dora to 179.0 mgL^{-1} in Beiruti site. Increasing in calcium concentration at July may be attributed to dissolution processes of Calcium Carbonate minerals with onset of water increase and high levels of water in Tigris River, this increase in the Calcium concentration was directly related to total hardness In river water, this is consistent with Salwan *et al*. (2019), who showed that Calcium concentrations in Tigris River water ranged between 57-116 mgL^{-1}.

Magnesium concentrations ranged from 38 mgL^{-1} in Medical City site at September to 18.66 mgL^{-1} in Medical City site at December. Increasing Magnesium concentration may be attributed to processes of dissolving minerals and rocks containing Magnesium with increasing drainage of river, in addition to solid and dissolved city medical materials releases that may contain Magnesium. Results are consistent with Salwan *et al*. (2019), as they indicated that Magnesium concentration ranged between 39-21 mgL^{-1} for Tigris River water.

Sodium ranged between its highest concentration in May, 101 mgL^{-1} in both sites after Diyala River meets Tigris River (Al-Tuwaitha) and Salman Pak, lowest concentration in December was 27.6 mgL^{-1} in Medical City. Increasing in Sodium concentration in May in Salman Pak site may be attributed to increasing in discharge of wastes from Al-Rostamia station, in addition to increasing temperatures during May, which leads to an increase in evaporation from River basin and a lack of water releases to river, which leads to an increase in ion concentration in River water, It fits with Salwan *et al*. (2019), who showed that Sodium concentrations ranged between 63-81 mgL^{-1} in Tigris River water.

Highest concentration of Potassium in September 12.00 mgL^{-1} at site of Medical City. lowest concentration at December reached 0.31 mgL^{-1} in site of before Dora. Increase in Potassium concentration in Medical City site at September may be attributed to lack of water releases to River during this period and increase in amounts of evaporation from River basin as well as wastes and many dissolved solid materials released by Medical City, Results are consistent with Al-Noor *et al*. (2016), who showed that Potassium concentrations ranged between 1.6-12.6 mgL^{-1} in Tigris River water.

Concentration of soluble anions

Results of table 2 show that sulfate concentrations during study period for different sites ranged between highest concentration at September amounted to 297.60 mgL^{-1} in Medical City site to lowest concentration at December 46.00 mgL^{-1} in Beiruti site. Increasing of sulfate at September in medical city site may be due to increased discharge of medical city waste, results are consistent with Salwan *et al*. (2019), who showed that sulfate concentration ranged between 314-65 mgL^{-1} in Tigris River water.

Chloride concentrations ranged between highest concentration at September, 234.00 mgL^{-1} in Beiruti site, to lowest concentration at December 42.3 mgL^{-1} in Medical City site. High concentration of chloride in September may be attributed to increasing release of water used in human activities in washing, cleaning and materials containing Chloride such as cleaning powders and others to the riverbed, in addition to increasing temperatures in this month then increasing evaporation, and lack of water releases of River in this month, results is in line with Salwan *et al*. (2019), who showed that concentration of Chloride ranged between 31-103 mgL^{-1} for Tigris River water.

Bicarbonate concentrations ranged between highest at September amounting to 236 mgL^{-1} in Medical City site to

lowest at December 118 mgL^{-1} in Beiruti site. Increase in concentration of Bicarbonate in September may be due to increase in dissolution of limestone, rocks Carbonate minerals, results came in line with Al-Noor *et al*. (2016), they showed that concentration of Bicarbonate ranged between 212-662 mgL^{-1}, highest concentration of Bicarbonate at May.

Highest Carbonate concentration in June was 2.0 mgL^{-1} in Rashidiya site, while its concentration in most sites was very little., this may be due to low solubility of Carbonate minerals in water , results are consistent with Shukri *et al*. (2011), who indicated that Carbonate concentration ranged between 1.3-1.9 $mmolL^{-1}$ in Tigris River water in Baghdad

Biological characteristics

Table 1 shows that organic Carbon ion concentration ranged between highest at May 54.66 mgL^{-1} in Medical City site to lowest at November 17.0 mgL^{-1} in Rashidiya site , high concentration in Medical City site may be attributed to increasing in disposal of medical city wastes, as it contains many organic wastes, which increase its concentration in of May because of high tempretures in this months in Baghdad, this leads to an increase in evaporation from River basin and an increase in decomposition of organic matter in River due to the effects of high temperatures and the release of more Carbon ions to River water compared to other months, results are consistent with Falih and Rashid (2016), who showed that organic Carbon concentration was 70-1120 mgL^{-1} in Tigris River water in Baghdad.

Concentrations of Chemical Oxygen Demade (COD) ranged between highest at May of 179.66 mgL^{-1} in Medical City site to lowest at December of 65.00 mgL^{-1} in site of before Dora, increase at May in Medical City site may be attributed to increase in release of Medical City waste, which contains many organic materials and it associated with an increase in organic Carbon in same site and month, results are consistent with Muhammad (2017) when studying a number of hospitals within Medical City complex in Bab Al-Muadham region - Baghdad, he found the highest concentrations of COD amounted to 89- 1120 mgL^{-1} in Tigris River water in Baghdad in medical city site because of its discharge to Tigris River.

Heavy metals concentrations

Concentrations of lead during study period for different sites (table 2) ranged from highest concentration at July to 1.23 mgL^{-1} in Dora site while it was not present in water in months of November and December in site of Dora.

High lead concentration may be attributed to gas residues released by Dora Refinery and small minutes it carries for Pb which falls on Tigris River water, as well as an increase in temperatures in summer, especially in July, which led to an increase in evaporation from River basin and an increase in the concentrations of Pb in it, as for its winter fading in months of November and December, it may be attributed to increase in water releases of River from source and increasing in rainfall that leads to a decrease in Pb concentration and possibly fading into River water, results are consistent with Al-Obaidi (2014), which showed that Pb concentration was 0.359 mgL^{-1} in Tigris River water within Baghdad city and It was higher than permissible limits for concentration of micro nutrients and heavy metals in natural. waters according to World Health Organization (WHO, 1996) guide.

Cadmium concentrations ranged between highest concentration at September amounted to 0.18 mgL^{-1} in site of Medical City to lowest concentration 0.01 mgL^{-1} in many of studied sites, including Rashidiya, Beiruti, and Al-Dora at December and May.

Increasing in Cadmium concentration in Medical City site at September may be attributed to increasing in release of Medical City waste to River, with water releases of River from source and evaporation of water from River, results came in harmony with Jumah and Al-Anbari (2010), they showed that concentrations of Cadmium reached 0.021 mgL^{-1} in Tigris River water in Baghdad, and thus exceeded limits allowed by World Health Organization. at mgL^{-1} 0.06 Concentrations of Nickel ranged between highest September in Dora site to lowest concentration in most of months 0.01 mgL^{-1} at most sites. High concentration of Nickel may be attributed to heavy metals such as Nickel filtered by Al-Dora Refineries by gas waste loaded with a lot of many minutes and other materials such as hydrocarbons and others that fall on the River course, which caused an increase in concentrations of these elements such as Nickel in water especially in high-temperature summer months, such as September, which leads to increased evaporation of water from River and an increase in concentrations of heavy metals in it. results are consistent with Al-Ubaidi (2014) showed, that concentration of Nickel was 0.198 mgL^{-1} in Tigris River water.

Copper concentrations ranged between highest concentration at June amounting to 0.17 mgL^{-1} in Medical City site to lowest concentration in many sites, including Rashidiya and Beirut sites at June and May, respectively, as it reached 0.01 mgL^{-1}.

High concentration of Copper may be attributed to increasing in release of waste from Medical City site to River and increasing in concentration of these substances, especially in summer, to increase evaporation of River's water, results are consistent with Al-Obaidy (2014), who showed that Copper concentrations reached 0.043 mgL^{-1} in Tigris River water within Baghdad.

Boron concentration was among the highest concentration at July, amounting to 0.94 mgL^{-1} at site of after Diyala River meets Tigris River to lowest concentration at May was 0.06 mgL^{-1} in site of after Dora.

High concentration of Boron may be attributed to discharge of Rustamiyah station to Tigris River, as waste water contains Boron concentrations of up to 0.86 mgL^{-1} as well as drainage water which thrown to River containing concentrations of Boron coming from addition of various chemical fertilizers containing Boron to agricultural soil on banks of river, results are consistent with Issa (2018), who showed that Boron concentration ranged between 0.15-0.26 mgL^{-1} in Tigris River water. .

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