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Monthly accumulative effect of wastewater discharged from the medical city on the water quality of Tigris River in Baghdad City, Iraq

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ABSTRACT

The present study focused to assess the effects of hospital wastewater discharged from the Medical City Hospital in Baghdad to Tigris River. Two sampling sites were selected. The first was located to the north centre of Baghdad about 12 km as control (S_1). The second location was represented the discharge point of Medical City station (S_2). The water quality parameter of pH, EC, TDS, cations, anions, and heavy metals (Cd^{2+}, Cu^{2+} and Pb^{2+}) were studied during January to August 2022. The obtained results showed that the EC values were 591-1453 µs/cm (mean ± SD = of 809 ± 62.5 µs/cm) in S_1, while 475-1374 µs/cm (mean ± SD = 872 ± 64.5 µs/cm) in S_2. TDS values were 304-879 ppm (mean ± SD = 518 ± 40.0 ppm) in S_1 and 378-930 ppm (mean ± SD = 558 ± 41.5 ppm) in S_2 respectively. The results found that the highest value for total hardness in S_1 and S_2 were 249-354 ppm (mean ± SD = 29 5 ± 6.93 ppm), and 256-360 ppm (mean ± SD = 299 ± 6.57 ppm), respectively. The monthly accumulative concentrations were examined by assaying the elevated concentrations of TDS, Na^+ and Cl^-. The results showed that there were also significant differences ($p < 0.05$) in average TDS, Na^+ and Cl^- values on the monthly basis. The TDS value (%) was higher in August (58.25), compared to January, February, March, April, May, June, and July (54.37, 51.50, 44.83, 43.33, 33.43 and 25.26 respectively). The Na^+ and Cl^- values (%) were higher in August (54.44 and 50 respectively) compared to January, February, March, April, May, June, and July (53.3, 49.52, 37.21, 34.46, 38.49, 25.2 and 50, 48.90, 37.72, 36.01, 37.76, 25.09, 7.3) respectively. Also, it was concluded that over 50% of TDS, Na^+ and Cl^- discharges to Tigris River occurred in August compared to January and February. It was recommended that in the case of the Medical City station (S_2), we need to establish a methodology for systematic data monitoring, and to assess the negative-effect of wastewater on Tigris River.

Key word: Baghdad Park, Medical City, Accumulative, Wastewater, Tigris River.
Article type: Research Article.

INTRODUCTION

Rapid population growth, economic development, rising standards of living, and lax international enforcement mechanisms all exert pressure on limited resources (Drake 1997). Specifically, agriculture, industry, and home consumption are three areas of society where water shortage has resulted in tremendous competitions (Hummel 2006). The river-basin surface waters often experience pressures and changes as a result of anthropogenic activities. These practices are among the main reasons for the deterioration of water quality, which might endanger public health (Vieira 2003; Hussain *et al.* 2022). The development of human capabilities and the mishandling of water resources, especially in recent decades, have created a pollution problem that is getting worse every day, followed by the increase in population numbers and demand for water, so that water pollution has cast a shadow on public health in most parts of the world (Abas 2021). The water physico-chemical characteristics change depending on light penetration, where precipitation occurs, and its chemical composition. Only 10 to 25% of the wastes produced by hospitals are classified as hazardous wastes, and they pose a number of health problems (Chapmen & Kimstach 1992). The most prevalent pollutants in hospital wastewater include pathogenic bacteria, viruses, molecules from unused and expelled medications, halogenated organic compounds absorbable on activated carbon (AOX), radioisotopes, and organo-halogen chemicals (Emmanuel *et al.* 2005). Baghdad Medical City discharges wastewater into Tigris River without proper treatment. The lack of upkeep and the inadequate technological skills are the reasons given by local authorities. In Baghdad, typically only 30% of wastewater is cleaned; the remaining 70% just runs into the river untreated. More than 1.5 million m^3 of untreated water are thought to be entering Tigris River each year (Ali 2018). In Baghdad City, numerous physico-chemical and Environmental studies on Tigris river have been carried out (Al-Obaidi 2009; Razzak & Sulaymon 2009; Al-Bayatti 2012; Al-Ani *et al.* 2014; Falih 2016; Muhammad & Rajab 2017; Ewaid *et al.* 2018; Al-Ani 2019; Muften *et al.* 2019; Abas 2021). The present study aimed to determine the negative effects of wastewater on water quality of Tigris river and to assess the monthly accumulative effect of wastewater discharged from the hospital of medical city.

Site description

The study area includes two locations, the first at 33.437794 N, 44.342155 E to the north of Central Baghdad about 12 km as control, while the second at 33.343982 N, 44.373703 E represented the discharge point. The hospital of Medical City is a complex of several hospitals situated in Bab Al-Muadham, Baghdad, Iraq, discharging effluent wastewater directly to Tigris River without any treatment (once to twice daily in the morning and in the evening). The region is characterized by a semi-arid climate, values of temperature, evaporation, and rainfall are 38 ℃, 254 mm/year and 24 mm, respectively. Geologically, the study area is covered by the Quaternary deposits (Pleistocene; Jassim & Goff 2006).

MATERIALS AND METHODS

Water samples

Water samples were collected from two locations (Baghdad Park and Medical City; Fig. 1), to assess the effects of waste of Medical City on the water quality of Tigris River within Baghdad City from January to August, 2022. The name of stations and their locations are listed in Table 1. Water samples were generally collected in-site in three bottles of 1-L polyethylene with high quality for physico-chemical analysis. All samples were preserved in a refrigerated room (T ≈ below 5 °C) for further analyses. The tests were conducted according to APHA (2012). Water temperature, pH and electric conductivity were measured in-situ.

Table 1. The station names, symbols, and coordinates in the studied area.

locations	Symbol	E-latitude	N-longitude	Elevation (m)
Baghdad Park	S1	33.437794	44.342155	32
Medical city	S2	33.343982	44.373703	29

Laboratory work

Water samples of the two selected locations were analysed in Department of Chemistry, Water Research Institute, Ministry of Science and Technology, Iraq. The analyses were performed to determine the concentrations of Na^+ and K^+ using Flame photometer. The Cl^-, Ca^{2+}, Mg^{2+}, HCO_3^- and TH were estimated by titration methods. The SO_4^{2-} and NO_3^- were estimated using Spectrophotometer and Cd^{2+}, Zn^{2+}, Pb^{2+} using atomic absorption, while the pH, EC and TDS by pH meter, EC meter and Weight method respectively. All the tests of the field and lab works were made according of APHA (2012).

RESULTS AND DISCUSSION

The results of different physico-chemical concentrations in the studied area are presented in Table 2. The pH values were 7.13-7.78 (mean ± SD = 7.45 ± 0.048) in Baghdad Park station (S_1) and 7.19-7.79 (mean ± SD = 7.44 ± 0.046) in Medical City station (S_2). The lowest and highest mean values recorded in S_1 and S_2 exhibited that the water is alkaline. In the case of electrical conductivity (EC), it was found that it ranged 591-1453 µs/cm (mean ± SD = 809 ± 62.5 µs/cm) in S_1 and 475-1374 µs/cm (mean ± SD = 809 ± 62.5 µs/cm) in S_2, while TDS was 304-879 ppm (mean ± SD = 518 ± 40.0 ppm) in S_1 and 378-930 ppm (mean ± SD = 558 ± 41.5 ppm) in S_2 respectively (Fig. 2). Since the water of Tigris River is impacted by wastes from the Medical City site that are loaded with salts, dissolved materials, and other pollutants, the rise in the amount of dissolved solids in this station was due to the increased wastewater disposal to the river. These findings are in good agreement with those of Al-Ani *et al.*

(2019), who demonstrated that a rise in dissolved solids causes alterations in the water quality of Tigris River in this site. The present results found that the highest value for TH in S_1 and S_2 were 249-354 ppm (mean ± SD = 295 ± 6.93 ppm), and 256-360 ppm (mean ± SD = 299 ± 6.57 ppm) respectively.

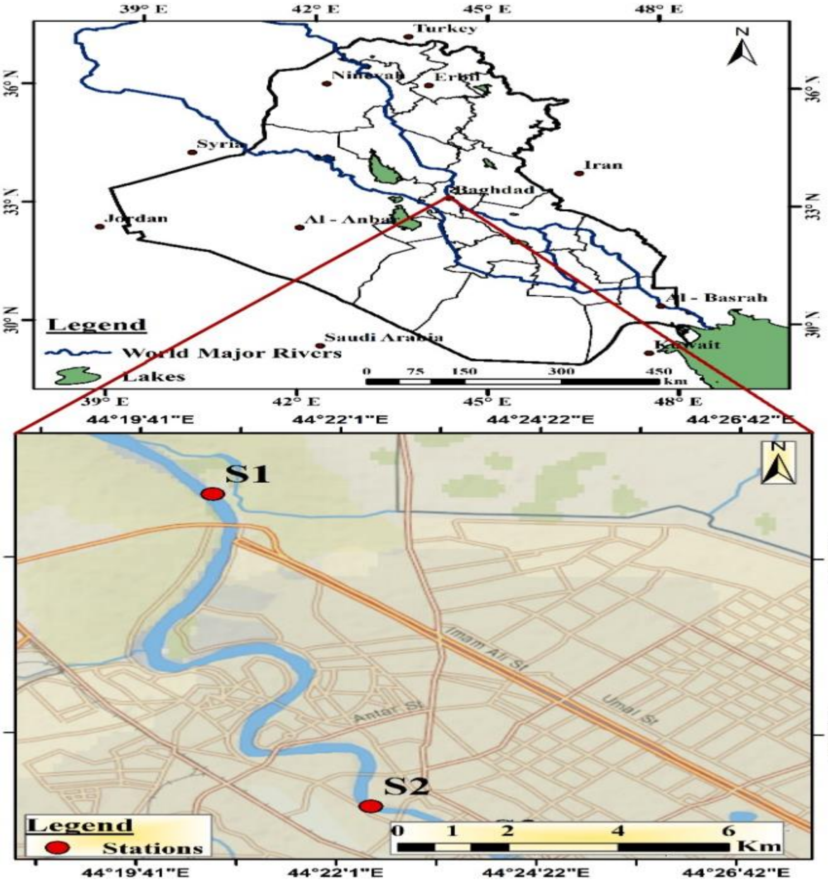

Fig. 1. Site Maps of the study area (Google earth).

In the case of cations, result showed that the range values of Na^+, in Baghdad Park (S_1) and Medical City stations (S_2) were 70-162 ppm (mean ± SD = 103 ± 6.35 ppm), and 87-180 ppm (mean ± SD = 112 ± 6.98 ppm); the range values of K^- concentration were 7.14-10.15 ppm (mean ± SD = 8.46 ± 0.208 ppm) and 7.36-10.34 ppm (mean ± SD = 8.71 ± 0.204 ppm) in S_1 and S_2, respectively. The Ca^{2+}-concentration ranged from 41.5 to 59.0 ppm (mean ± SD = 49.1 ± 1.21 ppm) and from 42.7 to 59.0 ppm (mean ± SD = 50.5 ± 1.15 ppm) in S_1 and S_2, respectively. Mg^{2+}-concentration ranged from 23.5 to 33.4 ppm (mean ± SD = 27.8 ± 0.684 ppm) and from 24.2 to 34.0 ppm (mean ± SD = 28.7 ± 0.670 ppm) in S_1 and S_2, respectively. The results of anions showed that Cl^- concentrations in S_1 and S_2 ranged from 55 to 125 (mean ± SD = 81.6 ± 5.19 ppm), and from 58 to 122 ppm (mean ± SD = 82.9 ± 5.13 ppm) respectively, while SO_4^{2-} concentrations ranged from 102 to 252 ppm (mean ± SD = 174.4 ± 11.5 ppm), and from 104 to 255 ppm (mean ± SD = 177.1 ± 11.6 ppm) in S_1 and S_2 respectively. Finally, The HCO_3 concentrations were 100-115 ppm (mean ± SD = 107.6 ± 8.19 ppm), and 134-156 ppm (mean ± SD = 143 ± 9.19 ppm) in S_1 and S_2 respectively. The cation and anion concentrations in the Medical City station (S_2) were significantly ($p < 0.001$) higher than in Baghdad Park (S_1) due to the high discharge sewage from Medical Hospital City in different times. In the case of NO_3, it was ranged between 2.03 and 9.91 ppm (mean ± SD = 5.52 ± 0.702 ppm) in S_1, while in S_2 ranged between 2.54 and 12.0 ppm (mean ± SD = 6.87 ± 0.877 ppm). The data measured in S_2 were much higher than those in S_1 exhibiting that the latter is considered as unpolluted water typically of cation, anions, heavy metals. The high values in the Medical City site may be due to discharge of wastewater from this station without treatment (Fig. 3). In Baghdad Park station (S_1), the concentrations of Cd^{2+}, Cu^{2+}, and Pb^{2+} varied from 0.010 to 0.019 (mean ± SD = 0.017 ± 0.001); from 0.002 to 0.066 (mean ± SD = 0.040 ± 0.003); and also from 0.041 to 0.123 (mean ± SD = 0.067 ± 0.005), respectively. The concentrations of Cd, Cu, and Pb at S_2 varied from 0.017 to 0.035 (mean ± SD = 0.020 ± 0.001); from 0.045 to 0.076 (mean ± SD = 0.042 ± 0.003); and from 0.059 to 0.141 (mean ± SD = 0.082 ± 0.005), respectively.

Table 2. Mean + SD and physic-chemical parameters concentrations of Tigris River of Baghdad Park and Medical City stations.

Parameter		Baghdad Park (S_1)	Medical City (S_2)
EC	Average	475-1374	591-1453
(μSsm^{-1})	Mean ± SD	(809 ± 62.5)	(872 ± 64.8)
pH	Average	7.13-7.78	7.19-7.79
	Mean ± SD	(7.45 ± 0.048)	(7.64 ± 0.046)
TDS	Average	304-879	378-930
(mg L^{-1})	Mean ± SD	(518 ± 40.0)	(558 ± 41.5)
TH	Average	249-354	256-360
(mg L^{-1})	Mean ± SD	(295 ± 6.93)	(299 ± 6.57)
Na	Average	70-162	87-180
(mg L^{-1})	Mean ± SD	(103 ± 6.35)	(112 ± 6.98)
K	Average	7.14-10.15	7.36-10.34
(mg L^{-1})	Mean ± SD	(8.46 ± 0.208)	(8.71 ± 0.204)
Ca	Average	41.5-59.0	42.7-59.0
(mg L^{-1})	Mean ± SD	(49.1 ± 1.21)	(50.5 ± 1.15)
Mg	Average	23.5-33.4	24.2-34.0
(mg L^{-1})	Mean ± SD	27.8 ± 0.684	28.7 ± 0.670
Cl	Average	55-125	58-122
(mg L^{-1})	Mean ± SD	81.6 ± 5.19	82.9 ± 5.13
HCO_3	Average	100-115	134-156
(mg L^{-1})	Mean ± SD	107.6 ± 8.19	143 ± 9.19
SO_4	Average	102-252	104-255
(mg L^{-1})	Mean ± SD	174.4 ± 11.5	177.1 ± 11.6
NO_3	Average	2.03-9.91	2.54-12.0
(mg L^{-1})	Mean ± SD	5.52 ± 0.702	6.87 ± 0.877
Cd	Average	0.010-0.019	0.017-0.035
(mg L^{-1})	Mean ± SD	0.017 ± 0.001	0.020 ± 0.001
Cu	Average	0.002-0.066	0.045-0.076
(mg L^{-1})	Mean ± SD	0.040 ± 0.003	0.042 ± 0.003
Pb	Average	0.041-0.123	0.059-0.141
(mg L^{-1})	Mean ± SD	0.067 ± 0.005	0.082 ± 0.005

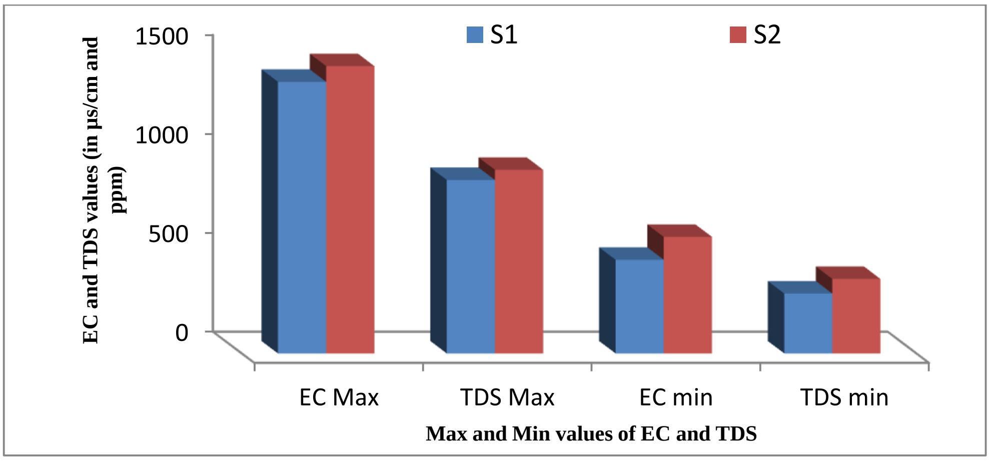

Fig. 2. Max and min values of EC and TDS in studied area.

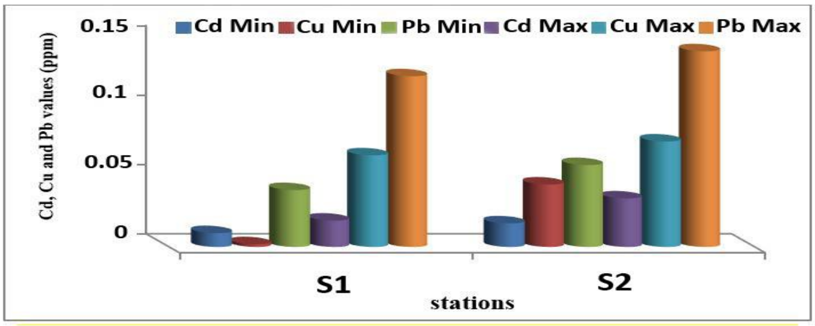

Fig. 3. Maximum and minimum concentration of Cd, Cu and Pb in the studied area.

There is a clear difference in the amount of waste discharged from the Medical City station (S_2). The quantity, quality, and timing of the waste's disposal into Tigris river are all factors that affect the concentrations. Comparing the chemical and physical parameters at S_1 and S_2 revealed that S_1 had higher concentrations of polluted parameters. Also, Noteworthy, the impact of wastewater disposal from medical hospital city is evident in the doubling of concentrations before to discharge. The concentrations of EC, Na^{2+}, and Cl^- were examined in order to determine the impacts of these two stations and their accumulative load (Table 3). According to the results of the present study, the mean concentrations of TDS, Na^+ and Cl^- exhibited an elevation in S_2 reaching to 568,115 and 85.4 ppm respectively with significant differences compared to S_1 (539, 107 and 74.4 ppm respectively). A highly significant differences were found in the concentrations of TDS, Na^+ and Cl^- between S_1 and S_2. The wastewater from S_2 on the left bank of the river contributes to raising the Na^+ and Cl^-, as well as higher values of TDS in surface water of Tigris River compared to other depths. The higher values recorded in S_2 was due to the elevated wastewater disposal without any treatment, and upraising human activities, which has increased the TDS, Na^+ and Cl^- levels (Fig. 4). To study the monthly accumulative effects/increased physiochemical characteristics at S_2 on Tigris River water within boundaries of Baghdad City, we examined TDS, Na^+ and Cl^- from January to August. The results showed significant differences ($p < 0.05$) in the average TDS, Na^+ and Cl^+ values for the months studied. The rate (%) elevations in the TDS values associated with August was 58.25 compared to January, February, March, April, May, June, and July (54.37, 51.50, 44.83, 43.33, 33.43 and 25.26 respectively). The increased rates of Na^+ and Cl^- in August were 54.44 and 50% compared to January, February, March, April, May, June, and July (53.3, 49.52, 37.21, 34.46, 38.49, 25.2% and 50, 48.90, 37.72, 36.01, 37.76, 25.09 7.3% respectively). The effects of wastewater disposal were observed for some parameters from Medical Hospital to Tigris River, indicating over 50% addition in the TDS, Na^+ and Cl^- during August compared to January and February.

Table 3. Statistical variables for the values of TDS, Sodium (Na^+) and Chloride (Cl^-) in the studied stations during January - August 2022.

	Total Dissolved Solid (TDS; ppm)		Sodium (Na^+) Concentration (ppm)		Chloride (Cl^-) concentration ppm	
Stations / Months	Baghdad Park	Medical City	Baghdad Park	Medical City	Baghdad Park	Medical City
January	347^h	386^g	80^e	89^{de}	60^f	61^f
February	398^g	421^{fg}	79^e	84^e	67^{ef}	66^e
March	440^f	451^{ef}	93^d	95^d	72^{de}	76^d
April	461^e	513^e	102^c	113^c	80^d	78^d
May	524^d	527^d	106^c	118^c	74^{de}	76^d
June	585^c	619^c	104^c	110^c	92^c	91^c
July	677^b	695^b	131^b	134^b	108^b	113^b
August	879^a	930^a	162^a	180^a	125^a	122^a
Mean ± SE	539 ± 61	568 ± 63	107 ± 10	115 ± 11	74.8 ± 7.8	85.4 ± 7.7
Range	347-879	386-930	79-162	84-180	60-105	61-122
$LSD_{0.05}$	4.06	20.3	6.00	10.4	8.46	4.74

CONCLUSION

In this study, we assessed the data of physio-chemical analyses as the water most important parameters for explaining the water quality in medical City Hospital waste at the discharging point in Tigris River. The significant spatial and temporal variations in the TDS, cations, anions, and heavy metals (Cd^{2+}, Cu^{2+} and Pb^{2+}) concentrations in water were observed. It was found that the disposal of Medical City Hospital has high effects on water quality parameters of Tigris river in Baghdad City. There is a need to establish a methodology for systematic data monitoring, for the assessment of water quality parameter of Tigris River water due to significant level of pollutants which had been disposed to this river.

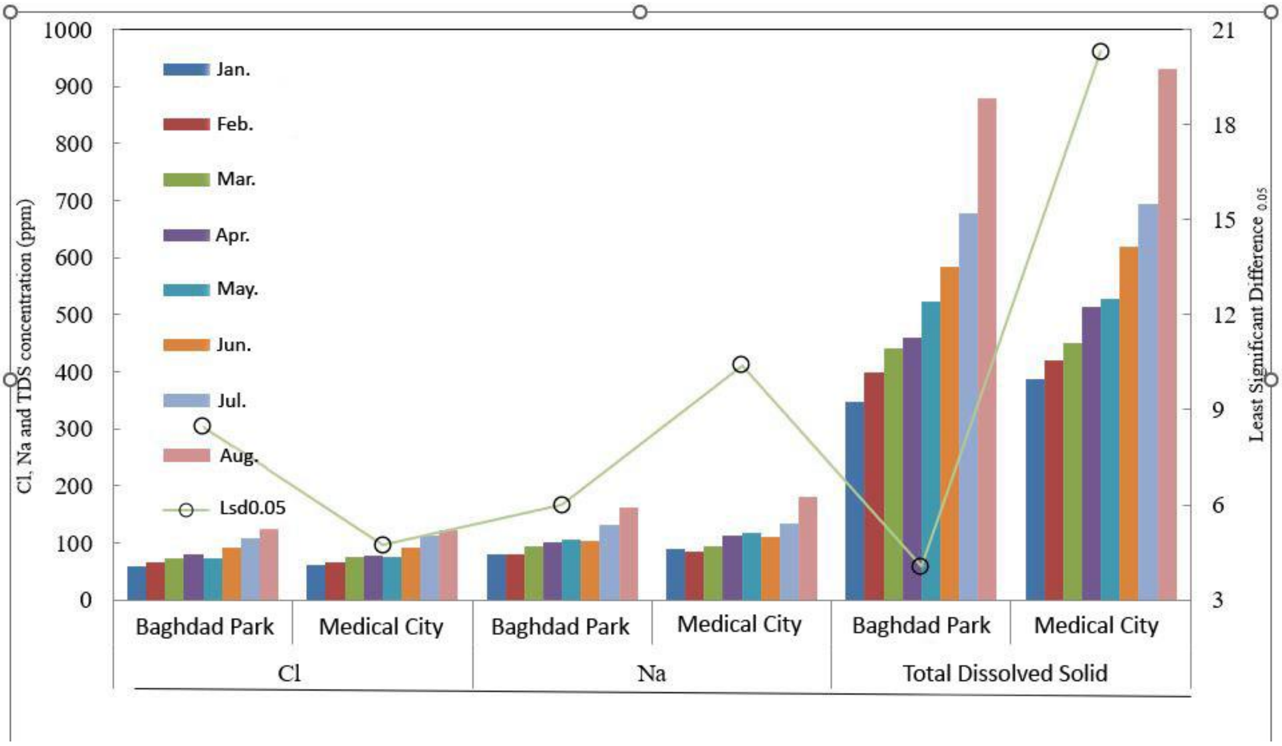

Fig. 4. Distribution of TDS, Na and Cl in Baghdad Park and Medical city stations during studied Months.

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