Evaluating the Effects of Medical City Wastewater on Water Quality of Tigris River

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Abstract

Physiochemical characteristics of Tigris river water were examined monthly to assess the possible impacts of wastewater discharged from Baghdad Medical City hospital for the period from October 2012 to September 2013. Four sites were selected during this study; the first was located about 500 meters before the Medical City Complex to act as control. The second was the discharge point of Medical City discharge. The third was almost 500 meters away south the second site, and the forth was located about 1500 meters away from the third site. Water samples were collected monthly from these four sites, at depth of approximately 10-20 cm of water surface and subjected for determination several physiochemical variables such as temperature, pH, Electrical Conductivity (EC), turbidity, DO, COD, BOD, total hardness, chlorides and nitrate. The obtained results showed that air and water temperature mean values varied from 13.0 ± 2.86 to 31.0 ± 5.28 C ° and from 12.0 ±3.12 to 29.0 ±4.33 C° respectively. Also, mean turbidity values were found to range from 10.0±5.64 to 138.0±14.58 NTU while EC mean value was situated between 621.0±44.67 µS/cm and 1549.0±162.83µS/cm. However, this study has found that the mean values of EC, turbidity, chemical oxygen demand, chlorides, total hardness, and nitrate in site 2 (discharge point) were significantly (P≥0.001) higher than those of other sites during the study period. In general, it was found that Tigris river water tends to be alkaline with pH mean values ranging from 7.0 ± 0.42 to 8.8± 0.68 while DO mean values varied from 2.5±0.62 to 9.6±0.94 mg/l. The BOD mean values were found to range from1.7±0.26to5.0 ±1.86 mg/l, while COD mean values varying from56.6±8.98 to688.6±112.42 mg/l. In addition, the current results have shown that total hardness mean values were very high and ranged between 235.0±24.56and 530.0±78.68 mg/l while chlorides mean values ranging from45.0±10.44 to 143.6±21.26 mg/l, but nitrate mean values were found with the range of 2.5±0.86and 28.8±4.98 mg/l. These results, however, have been found to be mostly exceeding those of the permissible limits for Iraqi and WHO standards for protecting surface water.

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Keywords: Tigris River; Medical city; medical wastewater

دراسة بعض الصفات الفيزيوكيميائية لمياه الفضلة الصحية لمدينة الطب وتأثيرها على نهر دجلة

الخلاصة

دُرست التغيرات الشهرية للخصائص الفيزيائية والكيميائية للمياه لتقييم نوعية مياه نهر دجلة وقياس تأثير ملوثات مستشفى مدينة الطب على النهر للمدة من تشرين الأول 2012 الى أيلول 2013. اختيرت أربع محطات للدراسة، تقع المحطة الأولى قبل مجمع مدينة الطب بحوالي 500 متر اذ تمثل محطة السيطرة، أما المحطة الثانية فهي تصريف ملوثات مدينة الطب الى النهر، تقع المحطة الثالثة على بعد 500 متر من المحطة الثانية، أما المحطة الرابعة فتقع على بعد 1500 متر من المحطة الثالثة. أخذت العينات شهريا من المحطات الاربعة على عمق (10-20) سم من سطح الماء تقريبا. واستخدمت لتحديد بعض المتغيرات الفيزيوكيمائية مثل درجة الحرارة والاس الهيدروجيني والتوصيلية الكهربائية والعكورة والاوكسجين المذاب والمتطلب الحيوي للأوكسجين والمتطلب الكيميائي للأوكسجين والعسرة الكلية والكلوريدات والنترات. وقد تراوحت قيم درجات حرارة الهواء والماء بين (13±2.86– 31±5.28 و12±3.12-29±33.4) مْ على التتالي، وقيم العكورة كانت بين (10±5.64– 138±14.58) نفثالين وحدة كدرة، أما قيم التوصيل الكهربائي كانت بين (621 ±44.67– 1549±162.83) مايكرو سيمنز / سم. إن مياه نهر دجلة كانت قاعدية حيث سجلت قيم الآس الهيدروجيني بين (7±0.42–8.8±0.68). بينما تراوحت قيم الأوكسجين المذاب (2.5±0.62– 9.6±0.94) ملغم / لتر، وتراوحت قيم المتطلب الحيوي للأوكسجين بين (1.7±0.26–5±1.86) ملغم / لتر، اما المتطلب الكيمياوي للأوكسجين فقد كانت قيمته بين (56.6±8.98–688.6±112.42) ملغم/لتر، وجد أن مياه النهر عسرة جداً إذ أن قيم العسرة الكلية قد تراوحت بين (235±24.56– 530±78.68) ملغم / لتر. أما بالنسبة لقيم الكلوريد فقد تراوحت بين (45±10.44–143.6±21.26) ملغم / لتر. اما قيم النترات فكانت (2.5±0.86–28.8±4.98) ملغم/لتر. أظهرت اغلب القيم من النتائج تجاوز الحد المسموح به للمواصفات العراقية ومنظمة الصحة العالمية لنظام صيانة الأنهار.

الكلمات المرشدة: نهر دجلة، مدينة الطب، مياه الصرف الصحي

INTRODUCTION

Tigris is the biggest river in Iraq and the main source of drinking water for Baghdad [1], any pollution of Tigris River may cause a direct pollution to Euphrates River and the related water sources since both rivers connected through Al Tharthar Lake [2]. Approximately, 20% of the world's population lacks safe drinking water and nearly half the world population lacks adequate sanitation, this problem is acute in many developing countries, which discharge an estimated 95% of their untreated urban sewage directly into surface waters, Iraq, which is one of the nine Middle Eastern countries, has insufficient fresh water [3]. According to UNICEF report, about 800 million people in Asia and Africa are living without access to safe drinking water [4].

Wastewater generated from hospitals usually contain pathogens, human tissues and fluids, pharmaceuticals, substances with genotoxic properties, chemical substances, heavy metals, and radio-active wastes, which may endanger public health, and contribute to oxygen demand and nutrient loading of the water bodies and in the process promote toxic algal blooms and leading to a destabilized aquatic ecosystem, if discharged without treatments into water bodies [5]. One of the chief environmental problems putting by the hospital sewages is their discharge, in the same way as the urban typical effluents, towards the urban sewer network without initial treatment [6].

There is a likeness between hospitals and household wastewater, but it is considered as containing hazardous compounds and microorganism and include bacteria, viruses, worms, hazardous materials and chemicals sterilized as well as radiation development laboratory waste, which is characterized by the occurrence of chemicals toxic, thus the wastewater of the hospital daily change their quantity and quality from one hour to another and from one season to another, wherever the discharge (300-1000 liters/person/day) hence the critical need for wastewater treatment supplied by the hospital to reduce the threats that may be caused these pollutants to civilian sources [7].

The physical and chemical properties are great important in aquatic systems through their influence in determining the quality of good water. This is done by comparing these factors with global standard specifications for water quality, considering that water plays a major role in maintaining the health and safety of the consumer (Table 1). These factors were continuously varying depending upon the nature of geological and climatic conditions of the study area [8].

Materials and Methods

Medical City is a complex of several hospitals situated in Bab Al-Muadham, Baghdad, Iraq. It is on the east bank of the Tigris River (Rusafa) and located between Sarafiya and Bab Al-Muadham Bridges [9]. These Medical facilities discharge the wastewater (once to twice daily in the morning and in the evening) directly into Tigris River without any local treatment.

Four sites were selected for water sampling where the first site was located around 500 meters before the Medical City Complex to act as control. The second was the discharge point of Medical City discharge. The third was about 500 meters away south the second site, and the forth was located almost 1500 meters away from the third site (Figure 1).

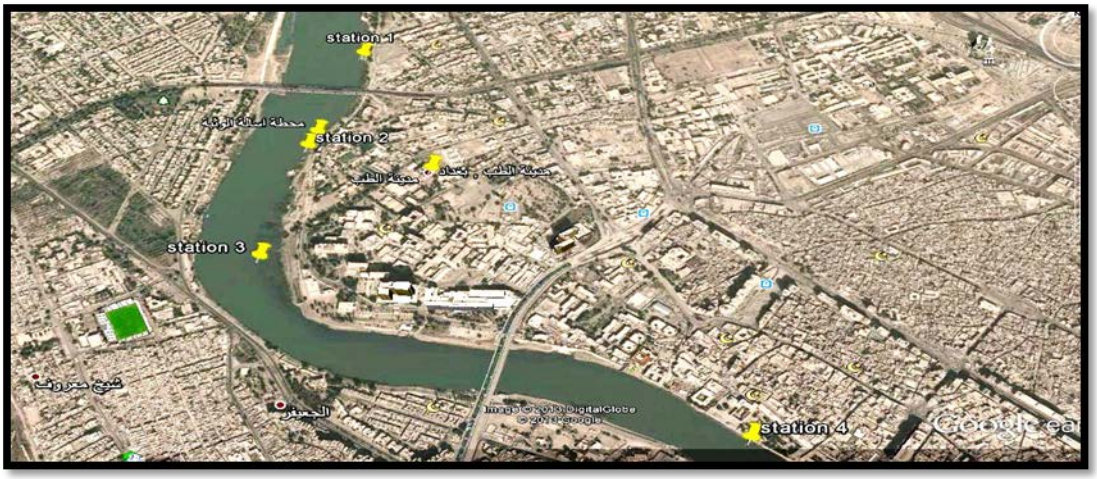

Figure (1). Sampling sites on Tigris River: Map from (Google Earth Pro)

Samples were collected monthly during period extended from the October 2012 to September 2013 from the four sites at depth (10-20) cm surface water approximately, sterilized dark Winkler bottles 250 ml use for Dissolve Oxygen and Biological Oxygen Demand, sterilized plastic bottles used for physicochemical analysis[10]. The collected water samples were subjected to chemical tests shown in Table 1.

Table (1). Physical and chemical parameters examined during the study and the methods references

NO.	Parameters	References
1	Temperature	[11]
2	pH	[12]
3	Electrical Conductivity	[13]
4	Turbidity	[14]
5	DO and BOD	[10]
6	Chloride ion	[14]
7	Total Hardness	[14]
8	Nitrate	[14]
9	Chemical Oxygen Demand	[10]

Results and discussion

The air and water temperature values in this study were varied from the lowest mean values (13.0 ± 2.86 and 12.0 ±3.12 °C) which were recorded in site1 in winter and the highest mean values (31.0 ± 5.28 and 29.0 ±4.33 °C) have been found in summer at site 4 (Figure 2 and 3).

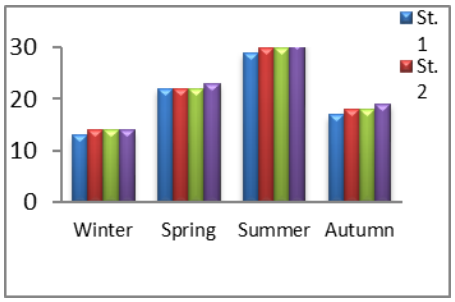

Figure (2). Seasonal variation of air temperature in Tigris during study period

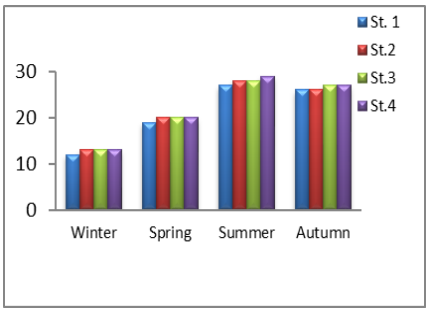

Figure (3). Seasonal variation of water in Tigris River during study period

It is clear that Tigris River was affected by the surrounding air temperature, the results showed high temperature in summer months and low temperature in winter months. These findings had also achieved at same conclusion with other studies in same area [11 and 12], and in different parts of the world [13 and 14]. There are no effects of Medical city discharge point on the temperature of the river.

The present study results showed that the highest value of water pH was 8.8 ± 0.68 in summers at site-1, which considered alkaline; while the lowest value was 7 in winter at site-2, which slightly acidic (Figure 4).

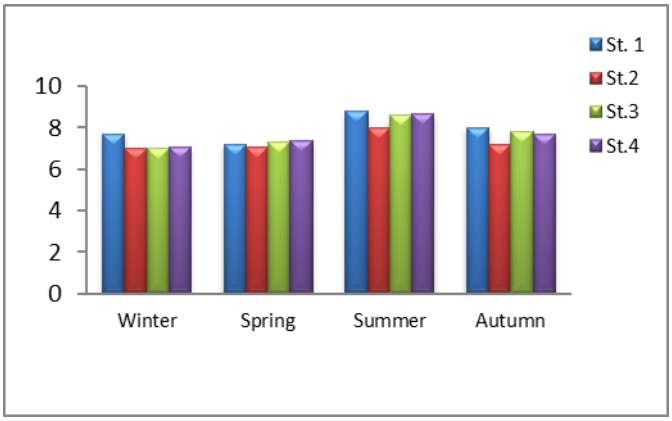

Figure (4). Seasonal variation of pH in Tigris River during study period

High pH during summer and autumn might resulted from the rate of photosynthesis by dense phytoplankton blooms and this leads to consumption of large amounts of carbon dioxide in water [15], as well as the excessive using of $CaCO_3$ to control pipe corrosive [16], in addition to that the effects of sand storm which increasing $CaCO_3$ concentration in water, also one of the important factors

influencing water pH, was the rainfall which occurs during winter. The rain is naturally slightly acidic due to the carbon dioxide dissolved in it [17].

The pH mean value particularly of discharging point was almost similar that of hospital wastewater in France as reported by [6] who suggested to be due to the presence of pollution, or may be related to the degradation of organic materials that produced dissolved carbon dioxide which leads to forming HCO_3 with low temperature and increasing hydrogen ion as concluded by a recent study [18]. In addition, the present data were similar to those reported by [19] and [20].However, these mean pH values were within Iraqi, WHO and American standards.

In case of electric conductivity, this study has found that highest mean value (1549.0±162.83µS/cm) was in autumn at site-2 while the lowest mean value (621.0±44.67 µS/cm) was in spring at site-1 (Figure 5).

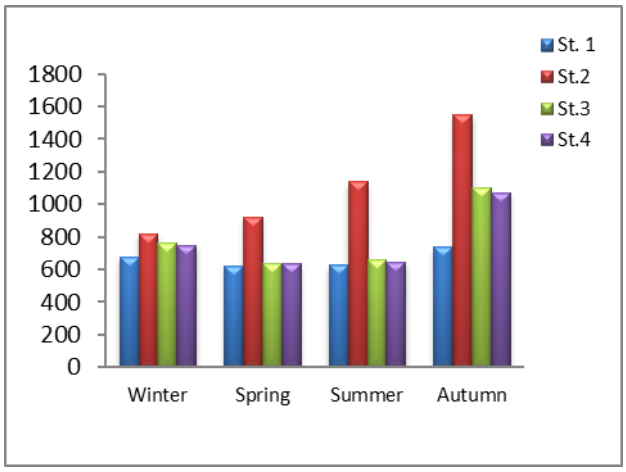

Figure (5). Seasonal variation in EC in Tigris River during study period

Mustafa [21] Showed that the range of EC value in Tigris River was 689-1386 µS/cm, while [22] recorded that the maximum value of E.C. in Tigris River was 1515 µS/cm, whereas the minimum value for E.C. 953 µS/cm. However, these results are almost similar to the current data.

The obtained results reveal that the highest value of Turbidity was 138.0±14.58 NTU in winter at site-2, while the lowest value was 10.0±5.64 NTU in summer in site-1 (Figure 6). However, site-2 appears to have the highest mean value in all study time being a discharge point.

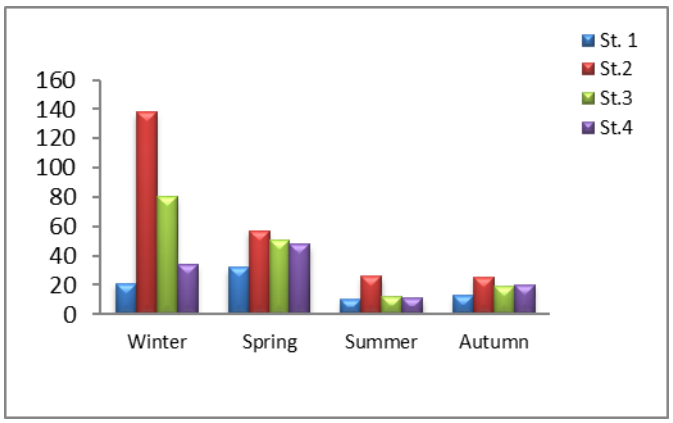

Figure (6). Seasonal variation of turbidity in Tigris River during study period

The turbidity increased during rainy seasons would be attributed to soil erosion in the nearby catchment and massive contribution of suspended solids from hospitals or factory sewage as suggested by [23]. In addition, surface runoffs and domestic wastes mainly contribute to the increased turbidity, and increased water levels in winter and water movement may lead to non-precipitation of suspended solids as reported by a recent study [24].

This study disagreed with the recent study carried out by [25] in Iraq, which found that turbidity was increased during summer in addition to other works [26, and 27] but in India. Nevertheless, the current data are supported by those of [19] and [28] who found that the turbidity was increased in all locations during winter but decreased in summer.

The present results showed that the highest mean value of DO was 9.6±0.94mg/l at site-1 in winter, while the lowest mean value was 2.5±0.62 mg/l at site-2 in autumn (Figure 7).

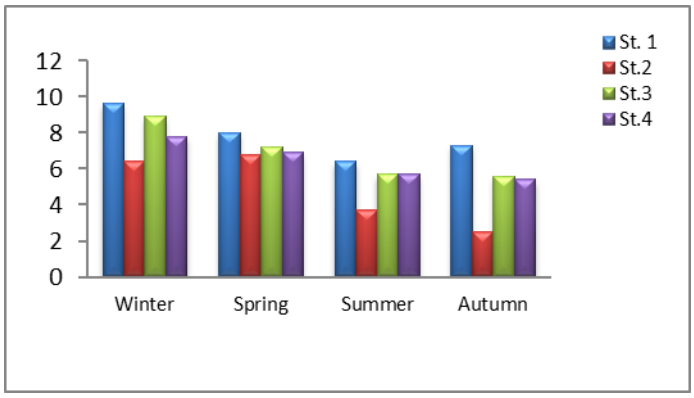

Figure (7). Seasonal variation in DO in Tigris River during study period

The DO mean value of site-2 was significantly lower than those of other sites due to high discharge wastewater. Tigris River usually shows elevated DO concentration in winter due to increased aeration caused by rainfall, in addition to the decrease of temperature in winter that increases the oxygen solubility [29]. DO in water may play an important role in metabolic activity of all aquatic organisms [30].

Iraqi, WHO and American standards for protecting river water mentioned that the optimal value of DO was more than 5 mg/l while [31] stated that the minimum values for DO is 4.5mg/l, but [32] reported that DO concentration of 9.0 mg/l is an optimal, 7.0 -8.0 mg/l acceptable, and 3.5 – 6.0 mg/l poor.

The results of current study were similar to those of a recent work [33], which reported a range of 4.0 – 6.77 mg/l on Tigris River while other study [34] on Soan river– Pakistan has found a range of 4.6-9.3 mg/l.

Regarding water BOD level, the current work has shown that the highest mean value (5.0 ±1.86 mg/l) was recorded in site-3during winter season while the lowest mean value (1.7±0.26mg/l) was in site-1 in summer (Figure 8).

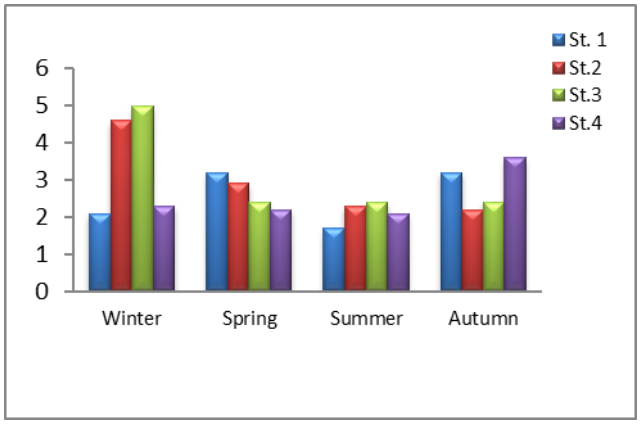

Figure (8). Seasonal variation in BOD in Tigris River during study period

Generally, the increased BOD mean value in winter may be due to the organic matter in large quantities discharged by rainfall and increased water temperature causing the decay of the organic substances and subsequently increased BOD levels as recommended previously [35].

The data of this study were much higher than those reported by [36] of similar work on Tigris River but lower than those reported by [37]. Unpolluted waters typically have BOD values of 2 mg/l or less, while those receiving wastewaters may have value up to 10 mg/l [38].

For chloride ions, the current result showed that the highest mean value of was 143.6 ± 21.26 mg/l in winter at site-2, while the lowest value was 45.0 ±10.44 mg/l in spring at site-1 (Figure 9). The Cl^{-1} mean valueinsite-2 was significantly ($p \geq 0.001$) higher than those of other sites because the high discharge sewage.

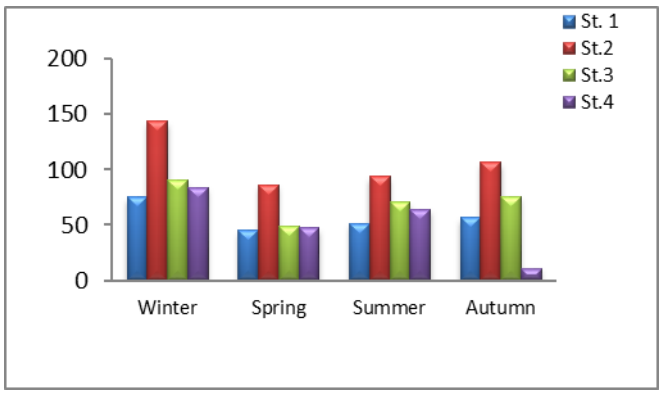

Figure (9). Seasonal variation in chloride ion in Tigris River during study period

The current results were complied with those of other study [39] but lower than those reported by [37]. The Cl^{-1} concentration was within the permissible limit for Iraqi, WHO and American standards for river water, which was 200 mg/l.

The current results found that the highest value for T.H. was 530.0±78.68 mg/l in winter at site 2, while the lowest value was 235.0±24.56 mg/l in spring at site 2 (Figure 10).

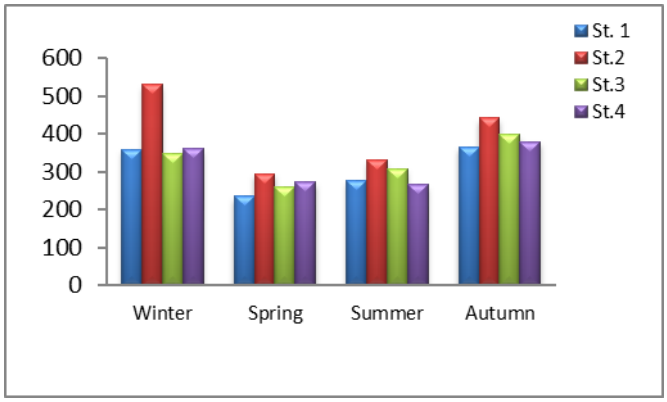

Figure (10). Seasonal variation in total hardness in Tigris River during study period

This study agreed with results of other studies [40, 19 and 25]. USEPA [31] classified waters according to $CaCO_3$ as the following: 50-150 mg/l is moderator hard water, 150-300 mg/l hard water, and more than 300 mg/l very hard water. From these results, Tigris river water is considerable as hard to very hard water being has a range of 235.0±24.56 -530.0±78.68 mg/l. However, these results were similar to those found by [41].

In case of NO_3^-, the highest mean value was 28.8 ± 4.98 mg/l in spring in site-2, while the lowest value was 2.5 ± 0.86mg/l in winter in site-4 (Figure 11).

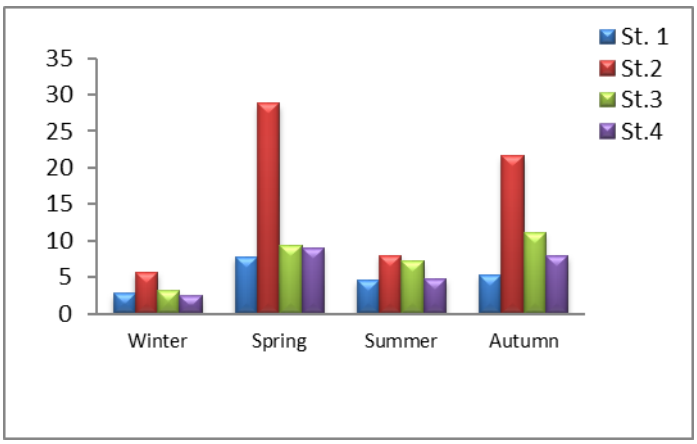

Figure (11). Seasonal variation in nitrate in Tigris River during study period

The current results are supported by those reported by [37] who examined similar variables of Tigris river water samples. However, mean value of NO_3 found in this study was within the permissible limit for both Iraqi and WHO standards, which was 15 mg/l.

The present study data showed that the highest value of COD was 688.6±112.42mg/l in autumn at site-2, while the lowest value was 56.6±8.98 mg/l in summer at site-1 (Figure 12).

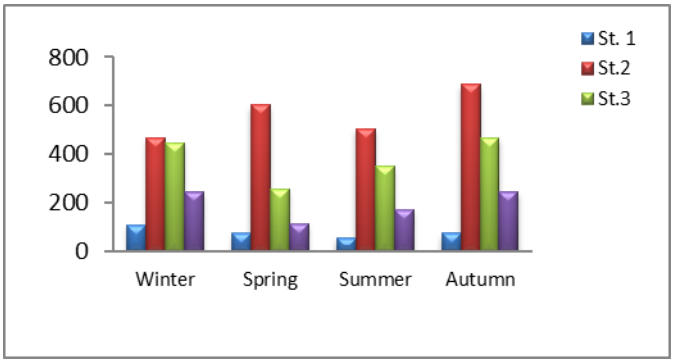

Figure (12). Seasonal variation in COD in Tigris River during study period

The COD results from site-2 were significantly ($P \geq 0.001$) higher than those of other sites being discharge point, in addition to high organic matter in this site, which coincided with undetectable oxygen throughout several months during the study period. These results are similar to those found by [14], but in a work of Greater Zab river and lower than those reported by [42] on Iran hospital wastewater, and also lower than those of [6] France hospital wastewater. However, the mean value of COD is higher than that of permissible limit of Iraqi river standards.

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