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Physicochemical Characteristics and Trophic State Index of shatt Al-arab River, Iraq

Najlaa H. Adlan Dunya A. Hussain Al-abbawy*
[1]Department of Ecology, College of Science, University of Basrah., Iraq.
*dunya.hussain@uobasrah.edu.iq

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Abstract.

The conditions of the Shatt Al-Arab River, southern Iraq, have significant effects on the nutrient content of the River. An attempt was made to assess the status by applying Carlson's trophic state index (CTSI). The River was surveyed from December 2019 to November 2020. Samples were taken from 12 stations along the course of the River. The field measurements and laboratory analyses (total phosphorous and chlorophyll-a) indicated that the CTSI values of the 12 stations were between 43.092 and 50.393. Thus, the stations were classified between mesotrophy and eutrophy. The CTSI values were higher at the end of the spring and summer seasons and lowest in winter. The physicochemical parameters of the water temperature (WT) ranged between 14.7 and 34.2 °C, pH ranged from 7.2 to 8.4, electrical conductivity ranged between 1.62 mS/cm and 10.15 mS/cm, DO was 5.1–9.8 mg/L, SD depth transparency rate was between 0.35 m and 0.95 m, Total phosphorus TP ranged between 2.56 mg/L and 16.05 mg/L, and the Chlorophyll-a concentration was between 0.4 mg/L and 32.4 mg/L. The eutrophication was significantly higher due to the direct discharges of untreated domestic, industrial and agricultural wastewater and high salinity during the summer season, which affects CTSI values.

Keywords: Shatt Al-Arab River, Carlson's trophic state index, Secchi disk transparency, total phosphorus, Chlorophyll-a.

Introduction

Rivers' physical, chemical, and biological parameters are important to provide a database for further research and assess water quality for irrigation, fish farming, and drinking uses (Al-Tememi *et al.*, 2015; Lateef, 2020). Dischargeable wastewater and industrial waste affecting the properties of natural water is one of the most serious water pollution problems. These wastes may change the nature of the aquatic environment; for example, fertilizers encourage the growth of plankton, algae, and plants (Dar *et al.*, 2014). This phenomenon may be due to the breakdown of untreated waste by the activity of bacteria into simple compounds, such as nitrates, sulfates, and phosphates (Aljoborey and Abdulhay, 2020). The Shatt al-Arab River also receives large quantities of nutrients and other compounds resulting from human activities (e.g., toxin input, suspended solids, or household wastewater, such as chlorinated hydrocarbons, detergents, and pesticides), which affect biological communities and have long-term effects on surface and groundwater resources (Gatea, 2018). With industrialization and the increase in population, the range of water needs has increased with the demand for quality water (Lateef, 2020). Rivers and streams are the main sources of nitrogenous and phosphorous compounds in many water bodies; thus, water quality in rivers must be monitored (Grochowska and yrak, 2009; Al-Aboudi *et al*., 2018).

Trophic state index (TSI) is the total weight of living mass in a water body at a specific place and time. It is the biological response to adding nutrients to water bodies. Carlson's TSI (CTSI) mainly calculates the trophic index with the help of three variables, namely, chlorophyll-a (Chl-a), transparency, and total phosphorous (TP) (Devi Prasad and Siddaraju, 2012). Changing currency fluctuations of salinity force other Physicochemical parameters to make the trophic state index (TSI) of the Shatt Al-Arab River, Iraq, change over time.

The present study aims to evaluate the nutritional levels of the Shatt Al-Arab River in Basra Province, southern Iraq, using the TSI and to evaluate the effects of nutrient loads on the environment.

Materials and methods

Study area

The Shatt Al-Arab River is the main source of fresh water in Basra Province. It consists of the Tigris and Euphrates Rivers' confluence north of Basra. The course of the river extends to the Arabian Gulf for a distance of 204 km. The river runs in the southeast direction to flow into the northwest part of the Gulf, south of the city of Al-Faw. Human activities and the progress of the saline waterfront from the Arabian Gulf, in addition to the discharge of industrial sewage and surface runoff for agriculture directly into the river without any previous treatment, affect the water quality and biodiversity in the Shatt Al-Arab River (Yaseen *et al*., 2016; Al-Asadi, 2017).

Field sampling and analytical procedures

Water samples were collected from the 12 selected sites (Table 1 and Figure 1) monthly from December 2019 to November 2020. Standard methods were adopted to collect and preserve samples along the Shatt al-Arab River, filtered using Millipore filter paper (0.45 μm). According to APHA (2005), the physical and chemical variables of water temperature (WT), electrical conductivity (EC), and (pH) were measured on-site by using a Lovibond multimeter SensoDirect 150. and dissolved oxygen (DO) in water was measured by Extech device. Light penetration (Secchi disk, SD) was also measured. The Chl-a concentration was determined according to APHA (1999). TP was determined by the method described in APHA (2005).

Table 1. Sampling locations and coordinates of the sampling stations at the Shatt Al-Arab River

Station number	Station name	Coordinates	
		E	N
St.1	Qurna	47.440523	31.005447
St.2	Shafee	47.540156	30.853923
St.3	Dair	47.5795	30.804273
St.4	Zwainy	47.6081	30.77801
St.5	Sindibad	47.780946	30.571524
St.6	Salheya	47.857636	30.510513
St.7	Mohella	47.926063	30.467139
St.8	Abu-flous	48.003299	30.462276
St.9	Seeba	48.258813	30.338062

St.10	Muamer	48.446656	30.007076
St.11	Nagaa	48.485711	29.975375
St.12	Ras-ALBisha	48.573948	29.944783

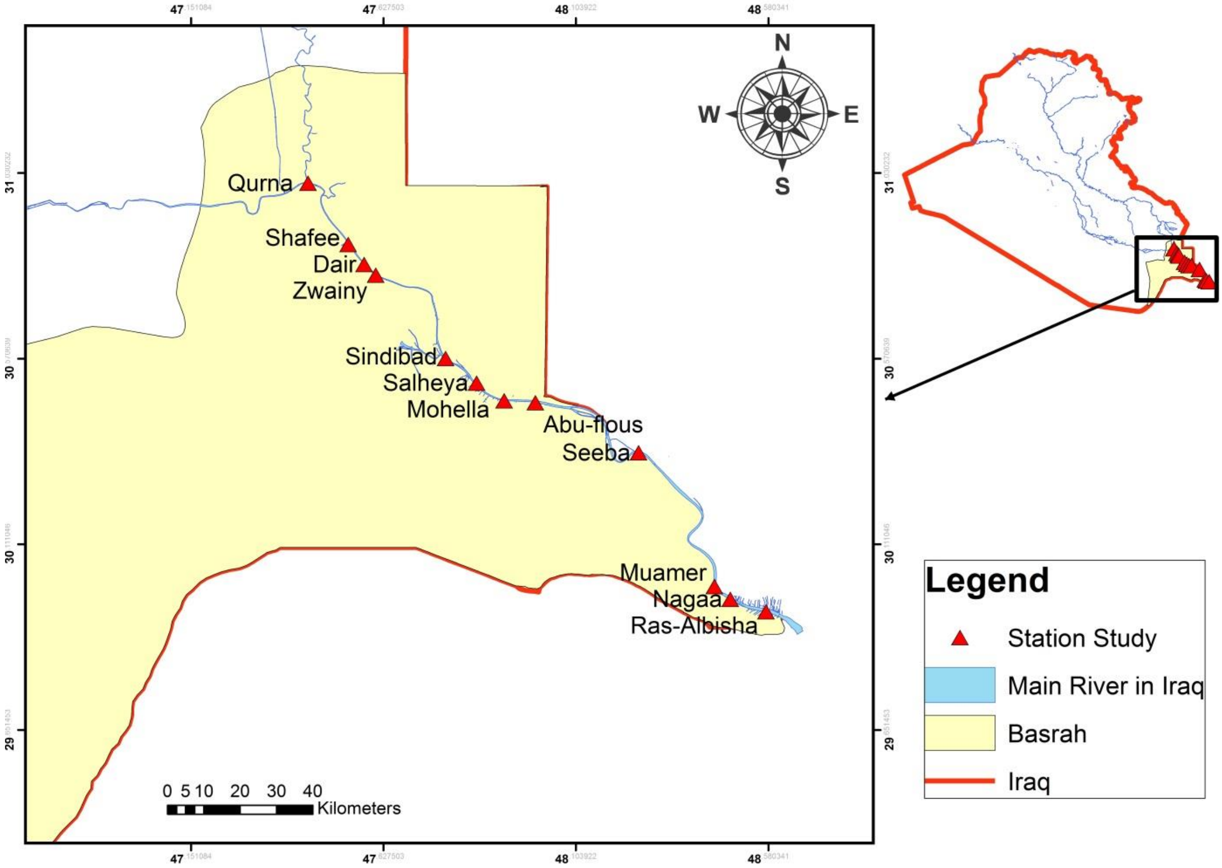

Figure 1. Map of the Shatt Al-Arab River showing the sampling stations.

TSI calculation

CTSI was calculated using the following formula as described by Carlson (1977):

TSI for Chl-a TSI (Chl-a) = [9.81*In Chl-a] + 30.6, (1)

TSI for Secchi depth TSI (SD) = 60 − [14.41*In SD], (2)

TSI for TP = [14.42*In TP] + 4.15, (3)

Average CTSI = [TSI(TP) + TSI(Chl-a) + TSI(SD)]/3. (4)

Table 2 shows the TSI grades and their ecological attributes.

Table 2. TSI grades and their ecological attributes

Class	TSI	Ecological attributes
1	<30	Oligotrophic
2	40 - 50	Mesotrophic
3	50- 70	Eutrophic
4	70-100	Hypertrophic

Statistical analysis

Statistical analysis SPSS software program was used in data analysis. Significant differences at a significant level ($p \leq 0.05$).

Results and discussions

Table 3 shows the variation of water parameters from the selected sites of the Shatt Al-Arab River. The WT varied significantly among the months, but no significant differences were observed among the study stations. During the study period, WT ranged between 14.7 °C and 34.2 °C, and the air temperature ranged between 17.3 °C and 49.3 °C. The highest values were recorded during summer and the lowest during winter. However, spatial differences existed in the WT between the study stations due to the season and sample collection times (Gupta and Paliwal, 2010). No statistically significant differences were observed. The pH values were within the Alkaline side among all the stations during the study period, which is a feature of the waters of southern Iraq as a result of the natural components of the Iraqi lands (Moyel and Hussain, 2015).

The EC values of the study areas increased gradually from the source (Station 1) to the downstream (Station 12) during most of the study period. Conductivity in the Shatt Al-Arab River was affected by factors such as the amount of fresh water, temperature, and the incursion of the marine salt front (Al-Nagar *et al.*, 2020). DO was used as a primary parameter for monitoring water quality. All stations showed increased DO levels during the winter and a decline during the summer due to the inverse relationship of DO with temperature (Hasan, 2016; Al-Asadi, 2017). The main causes of summer oxygen depletion are the low solubility of most gases, increased evaporation, lower water levels, higher degradation activities, and organic matter mineralization along the river (Gatea, 2018).

Table 3. Variation in the parameters from the selected stations of the Shatt Al-Arab River from December 2019 to November 2020

Parameters	Unit	Range
WT	°C	14.7 - 34.2
AT	°C	17.3 - 49.3
pH		7.2 - 8.4
Dissolved Oxygen (DO)	mg/L	5.1 - 9.8
EC	mS/cm	1.62 -10.15
Light Penetration Secchi disc (SD)	m	0.35 - 0.95
TP	mg/L	2.56 -16.05
Chlorophyll-a	mg/L	0.4 -32.4

The results showed that the TP concentration ranged between 2.56 mg/L and 16.05 mg/L, and high concentrations were observed during the summer (Figure 2). Disposing of domestic and agricultural wastewater within the Shatt Al-Arab River in some stations, especially the intermediate (Stations 5 and 6), contributed to the deterioration of the water quality of the Shatt Al-Arab River. An increase in the concentrations was also observed in Station 8 due to the proximity to the harmful effect of fertilizer discharge in the river, which was associated with high EC. The low TP concentration in late winter and spring was attributed to phosphorus consumption by aquatic plants and phytoplankton and phosphorus adsorption on silt and clay particles (Ping, 2006; Al-Ansari *et al.*, 2014). The temperature rise may also deplete the DO, which leads to high phosphorous concentrations in the water column. Most of the low values were recorded at Stations 11 and 12, which may be due to mixing with seawater or the high turbidity of the water in these stations, which led to the adsorption and precipitation of phosphorus (Al-Ansari *et al.*, 2014; AL-Haidarey *et al*., 2016). Chl-a levels fluctuated between 0.4 mg/L and 32.4 mg/L (Figure 3). The increase in Chl-a concentrations during the spring was often higher after the rains, especially if the rain pushed nutrients into the water, in addition to the rise in WTs (Ozcoasts, 2013), as well as biomass produced by aquatic plants and algae under light conditions (Sousa *et al.*, 2010; Jiménez, 2011). Dodds (2006) confirmed that increasing the nutrient concentration leads to increased Chl concentrations. Chl concentration also increases with phosphorous, encouraging the growth of plankton, algae, and plants (Al-Nashi, 2002). Other reasons for this increase included nutrient excretion (especially in cold seasons) and mineralization (especially in summer due to high temperature). The risk of contamination of water with organic matter and human activities and other economic uses of the river also exists. Figure 4 shows that the SD of transparency recorded the highest value of 0.95 m in March at Station 8 and the lowest value of 0.35 m in August at Station 5. TP concentration correlates negatively with transparency (Carlson, 1980), but a positive correlation exists between Chl-a and TP.

The CTSI of the Shatt Al-Arab River (Figure 5). The average values of the index during the study period were categorized as mesotrophy. A clear difference was found between the stations during the study period. The lowest value was recorded at 37.5422 at Station 11 in December and the highest was 54.3811 at Station 1 in April (Figure 6).

The CTSI values decreased during the winter due to the increased abundance of aquatic plants, especially the submerged species, which consume nutrients significantly and work to precipitate suspended matter, thereby causing turbidity and increasing light transparency (Silvion and Barbosq, 2015). Its values increased with the high temperatures and due to the lack of rain at the end of spring and summer, with a gradual decrease in the concentrations of DO and diminution of the water level in the Shatt Al-Arab River. This matter led to an increase in the concentration of nutrients with the continued discharge of sewage agricultural and industrial water, which increased phosphorous concentrations and promoted the growth of plankton and aquatic plants, especially in the northern and intermediate stations of the Shatt Al-Arab River. The high population density and organic wastes resulting from animal grazing increased the phosphorus concentration when decomposing (Devi Prasad and Siddaraju, 2012).

Al-Abbawy (2012) showed that the average TSI of the Shatt al-Arab River is 44.3. Mesotrophic status indicates that the river contains submerged aquatic plants and moderate nutrients. Hussain and Sabbar (2020) evaluated the CTSI for six stations in southern Iraq for two types of marsh, tidal and non-tidal marshes. The CTSI was between 47.59 and 61.96 from mesotrophic to eutrophic due to the direct discharges of untreated and agricultural wastewater. Transparency positively affects CTSI values, whereas TP and Chl concentrations have an inverse relationship.

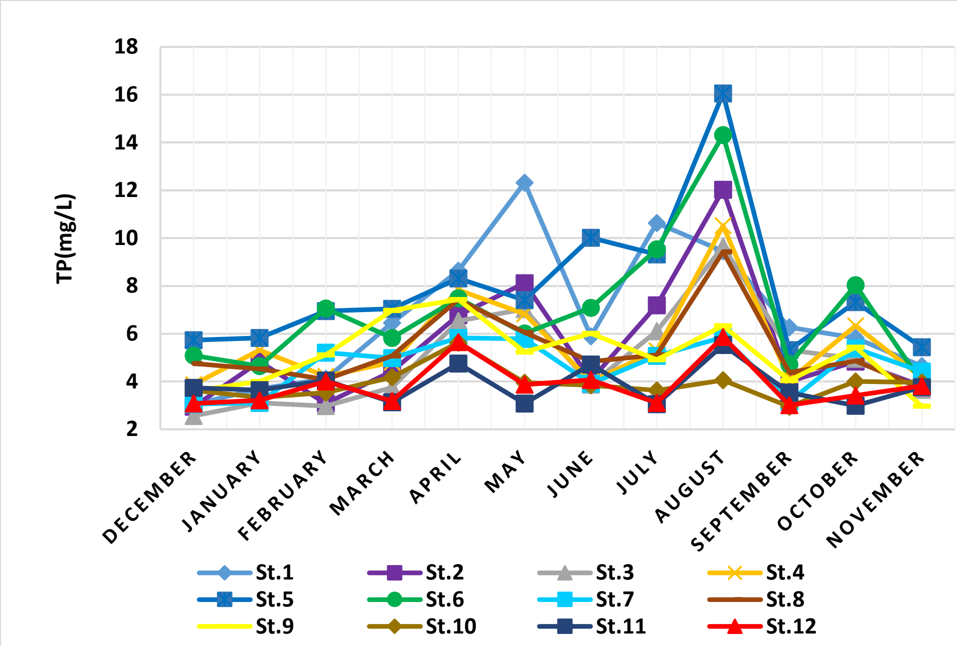

Figure 2. TP concentration (mg/L) for the stations along the Shatt Al-Arab River.

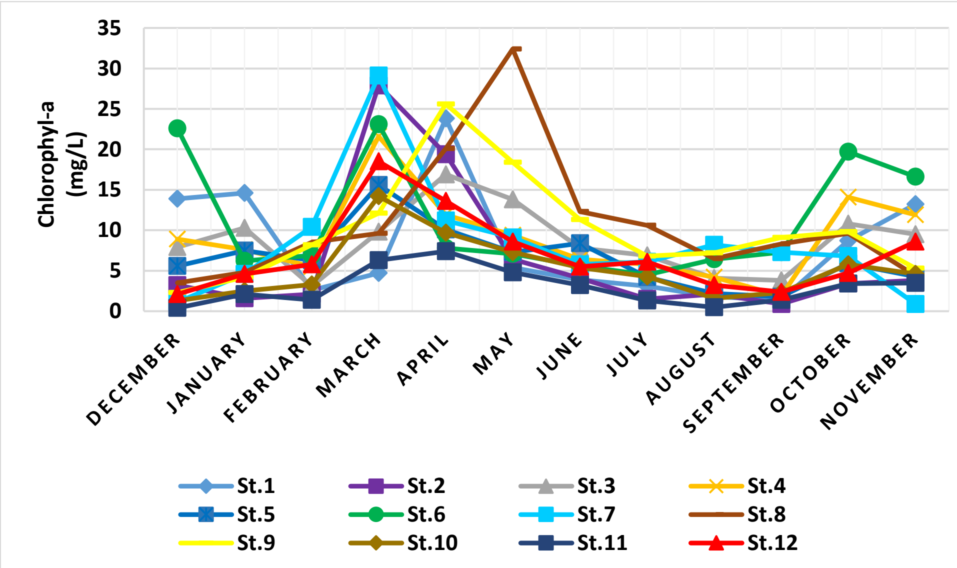

Figure 3. Chlorophyll-a (mg/L) for the stations along the Shatt Al-Arab River.

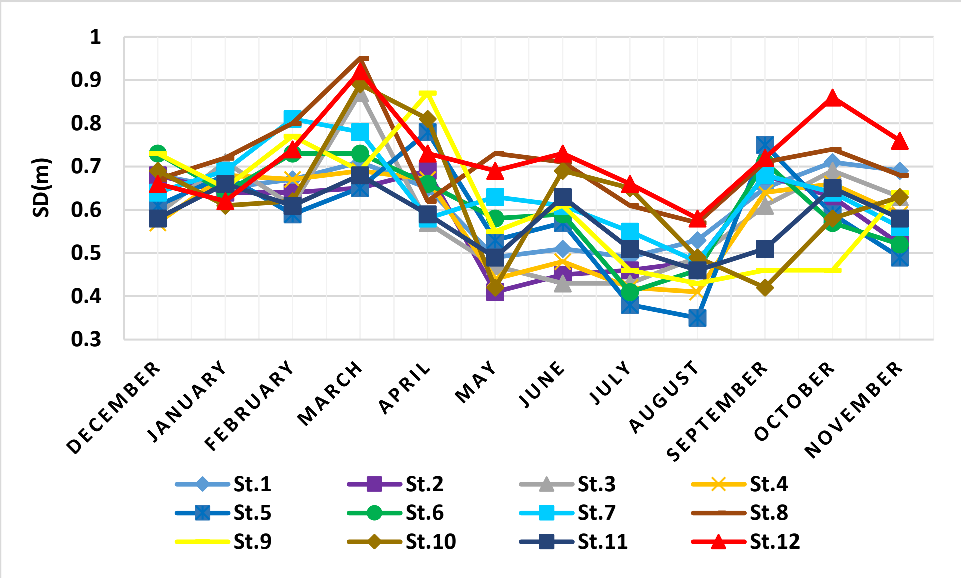

Figure 4. Secchi Disc (m) for the stations along the Shatt Al-Arab River.

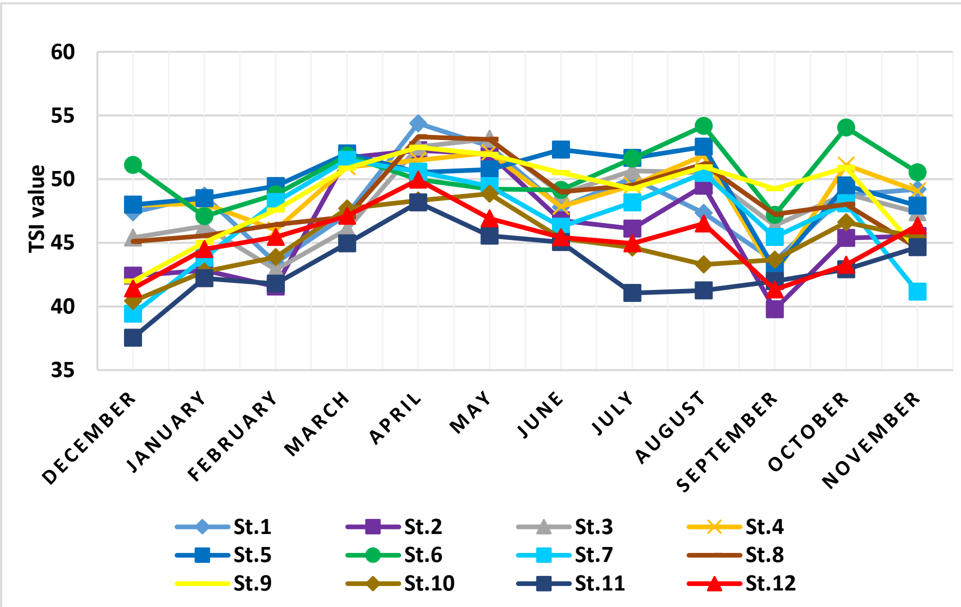

Figure 5. Carlson's Trophic State Index (CTSI) for the stations along the Shatt Al-Arab River.

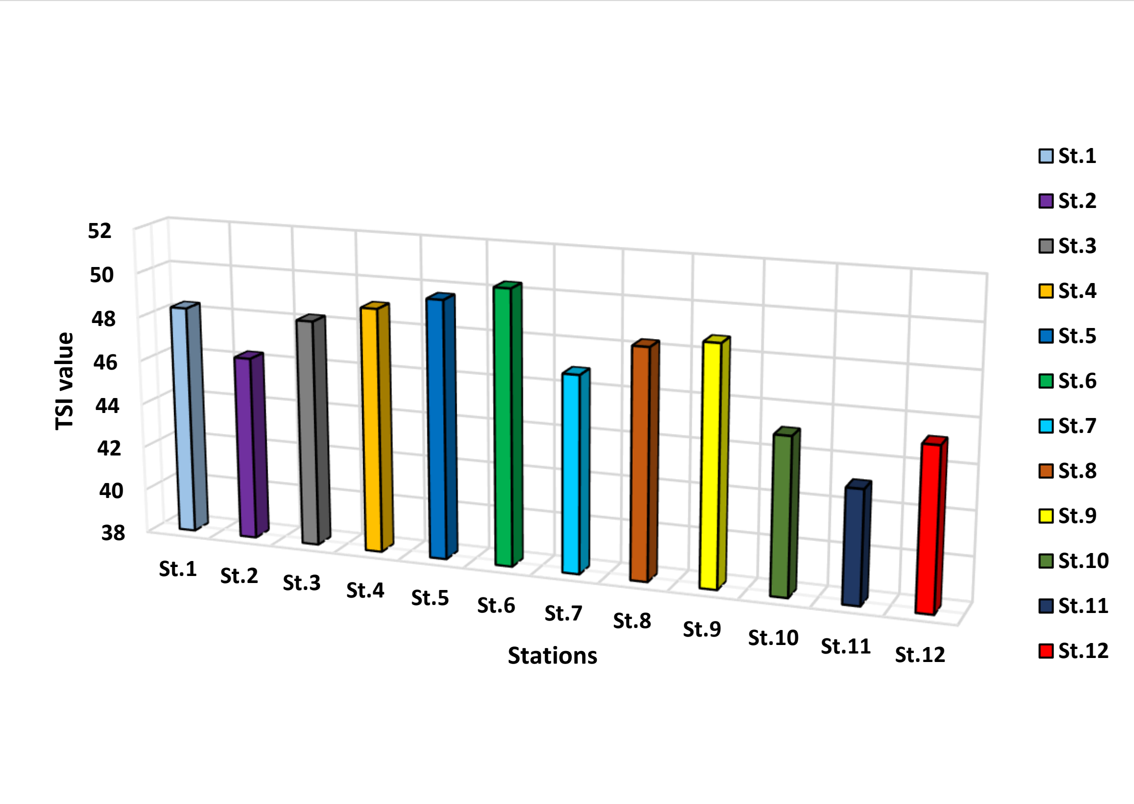

Figure 6. Annual average of CTSI values for the stations along the Shatt Al-Arab River.

Conclusions

This study revealed that CTSI values are low during the rainy season and moderate during the winter in the study area. The highest value was recorded during the summer due to the lack of rainfall and diminishing water levels in the river. The discharging of agricultural and industrial wastewater without any treatment may enhance the concentration of nutrients in the river.

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الخصائص الفيزيائية والكيميائية ومؤشر الحالة الاغتذائية في شط العرب، العراق

نجلاء هاشم عدلان   دنيا علي حسين الغباوي*
[1]قسم البيئة، كلية العلوم، جامعة البصرة، العراق.
dunya.hussain@uobasrah.edu.iq*

المستخلص.

ان ظروف شط العرب، جنوب العراق، لها آثار كبيرة على المحتوى الاغتذائي للنهر. تم تقييم الحالة الاغتذائية من خلال تطبيق مؤشر كارلسون للحالة الاغتذائية (CTSI). تم مسح النهر من أيلول 2019 إلى تشرين الثاني 2020. وأخذت عينات من 12 محطة على طول مجرى النهر. وأشارت القياسات الميدانية والتحاليل المختبرية (الفوسفور الكلي والكلوروفيل-أ) إلى أن قيم CTSI لمحطات الدراسة كانت تتراوح بين 43.092 و 50.393. وهكذا ، تم تصنيف المحطات بين mesotrophy و eutrophy. كانت قيم CTSI أعلى في نهاية فصلي الربيع والصيف وأدنى مستوى في فصل الشتاء. تراوحت المتغيرات الفيزيائية والكيميائية لدرجة حرارة الماء (WT) بين 14.7 و 34.2 درجة مئوية، وتراوح الاس الهيدروجيني بين 7.2 - 8.4 ، والتوصيلية الكهربائية بين 1.62 - 10.15 mS / cm ، وبلغ تركيز الاوكسجين المذاب 5.1-9.8 mg /L ، وكان معدل قراءة قرص ساكي SD بين 0.35 - 0.95 m ، بينما سجل الفوسفور الكلي TP تراكيز بين 2.56 و 16.05 mg / L ، وكان تركيز الكلوروفيل - أ بين 0.4 mg / L و 32.4 mg / L. بينت الدراسة ان زيادة تركيز المغذيات قد يعود الى التصريف المباشر لمياه الصرف الصحي المنزلية والصناعية والزراعية غير المعالجة والملوحة العالية خلال موسم الصيف ، مما يؤثر على قيم الدليل CTSI.

الكلمات المفتاحية: شط العرب، مؤشر كارلسون للحالة الاغتذائية، شفافية ، الفوسفور الكلي، الكلوروفيل-أ.