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Changes in Physicochemical Characteristics of Water along Shatt Al-Arab River

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Abstract: Physical and chemical factors can significantly influence natural lotic environments such as rivers by changing climatic conditions and human activities. This work to determined the concentration of elements and nutrient ions for the Shatt al-Arab River's water in Basra province. Water samples were collected from twelve sites along the course of the River. Shatt al-Arab River was surveyed from the monthly from December 2019 to November 2020 for physical and chemical measurements (Water Temperature, pH, EC, Turbidity, DO, Depth, TSS, Total Alkalinity, Total Hardness, NO_3^-, NH_4^+, $PO4^{\wedge}3^-$). The highest value of EC was 10.15 mS cm^{-1} of July in station 12. Dissolved oxygen values ranged from 5.1 to 9.8 mg l^{-1}. The highest value for total hardness was 3050.6 mg l^{-1} in July, and the total alkalinity was 190.02 mg l^{-1} at station 12 in June and July, respectively. The highest nitrate concentrations were 9.42 mg l $^{\wedge -1}$ in July at Station 5 and phosphate was 2.95 mg l^{-1} at Station 6 in July. The Shatt al-Arab water quality decrease during drought seasons results from high elements and nutrients. The water quality and biodiversity in the Shatt al-Arab River are also affected by two critical factors: human activities and the extent of the salt tongue from the Arabian Gulf, which can cause an increase in the concentration of the element level above the permissible level of the water systems. Therefore, this study aimed to find the difference in these variables' concentration and compare them with acceptable quantities of local standards.

Keywords: Shatt Al-Arab River, Physicochemical parameters, Nutrient, Water quality

Freshwater is a natural resource to sustain and ensure life continuity and support for ecosystems with primary productivity. It supports global water security, food security, and economic production (Everard 2019). Rivers represent a complicated system in which materials and energy are produced or added, stored, converted, and transported along a large gradient of different biotic and abiotic conditions (Humphries et al 2014). In general, the dominant source of organic matter and energy can be internal (autochthonous) or external (allochthonous) input, depending on local conditions. The rivers' hydrological system continuously changes due to reservoirs and industrial facilities, dam construction, and environmental conditions. Local conditions led to changes in water quality from one area to another (Schoonees et al 2019). Shatt Al-Arab River is formed by the confluence of the two main Iraq's rivers Tigris and Euphrates, at the Qurna city north of Basah. The River flows southeastwards to discharge into the Northwestern part of the Arabian Gulf. The River extends for an estimated distance of 204 km within Basra province. The Shatt Al-Arab River in Iraq faced an acute shortage of fresh water and extent of the salt tongue from the Gulf, as a result of the effects of the sharp decline in the plenty of freshwater due to Environmental and human influences, which caused great damage to drinking water purification and filtering stations and on agricultural and animal wealth and industrial facilities. A crisis escalated and reached its climax in 2018 and almost approached the humanitarian and environmental catastrophe. The objectives of the present study are to assess the water quality of Shatt al-Arab River and to explain the impact of natural factors such as the incursion of the extent of the salt tongue from the Arabian Gulf and climate changes in addition to the construction of dams in the upper rivers.

MATERIAL AND METHODS

Description of the study sites: The study area included Shatt al-Arab River that passes through the southeastern part of Iraq in Basra province. The temperature exceeded 45 degrees Celsius in June. The climate of the region is characterized by being subtropical to moderate continental, where the maximum precipitation is in December, while it disappears during the summer, the relative humidity may exceed 90% due to the location of Basra city near the Arabian Gulf and the prevailing winds are north to northwestern. They may become eastern to the southeastern or change direction. The Shatt al-Arab River is the main source of fresh water in Basra (Salim 2013). The Shatt al-Arab River consists of the confluence of the main Iraqi rivers, the Tigris and the Euphrates in the city of Qurna, north of Basra city, (currently, the Shatt al-Arab River drains water from the Tigris River only, as the Euphrates River has been closed in the Mdaina district

(Al-Tememi et al 2015, Al-Asadi 2017). The River flows southeast to the northwestern part of the Arabian Gulf (south of Al-Faw). The semi-daily tidal movement that affects the River's water level affects the River water. The water quality and biodiversity in the Shatt al-Arab River are affected by two critical factors: human activities and the extent of the salt tongue from the Arabian Gulf. Domestic and industrial wastewater is directly discharged into the River without prior or sufficient treatment, electric power plants, and agricultural runoff.

Field sampling and analytical procedures: Water samples were collected from selected twelve stations along the Shatt Al-Arab River (Fig. 1, Table 1), monthly from December 2019 to November 2020. Samples were preserved and analyzed according to the APHA (2012). Physical and chemical parameters, including water temperature (WT), air temperature (AT), electrical conductivity (EC), and pH were measured using the Lovibond Multimeter SensoDirect 150. Turbidity was determined using a Turbi Direct meter. Light penetration (Secchi disc) and depth were also measured, and the results were expressed in centimeters. The total suspended solids (TSS) amount, calcium and magnesium, and potassium ion were calculated according to the APHA (2012) method. Device model EXTECH was used to measure dissolved oxygen (DO) in water. Total alkalinity and total hardness were measured using the titration method (Tape and Aydin 2017). Reactive nitrates, ammonium ion, and reactive phosphate were estimated for water samples as described in APHA (2012).

Field sampling and analytical procedures: MS-Excel 2016, exported to SPSS for One-way ANOVA statistical analysis, collected all data. The correlation coefficient was also carried out using Dunkin test.

RESULTS AND DISCUSSION

Temperature is one of the most critical environmental factors affecting the aquatic environment's physical,

Table 1. Sampling locations and coordinates of sampling stations along Shatt al-Arab River

Station number	Station name	Coordinates	
		N	E
St.1	Qurna	31.005372	47.441698
St.2	Shafee	30.853923	47.540156
St.3	Dair	30.804273	47.5795
St.4	Zwaini Village	30.77801	47.6081
St.5	Sindibad	30.571524	47.780946
St.6	Salhiya	30.510513	47.857636
St.7	Mehella / Water Project	30.467139	47.926063
St.8	Abu-flous	30.462276	48.003299
St.9	Seeba	30.338062	48.258813
St.10	Muamer	30.007076	48.446656
St.11	Nagaa	29.975375	48.485711
St.12	Ras-ALBisha	29.944783	48.573948

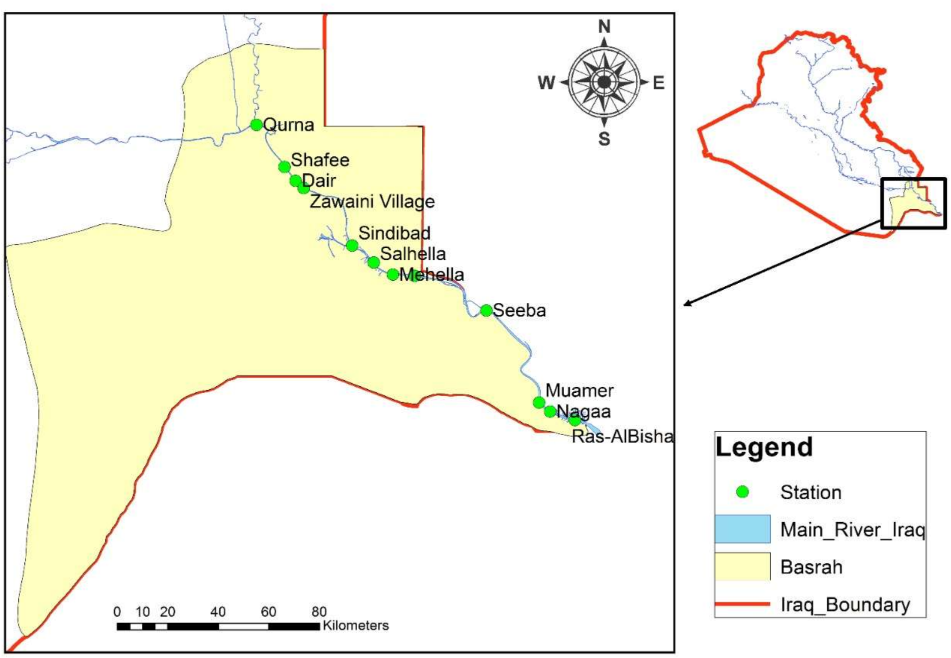
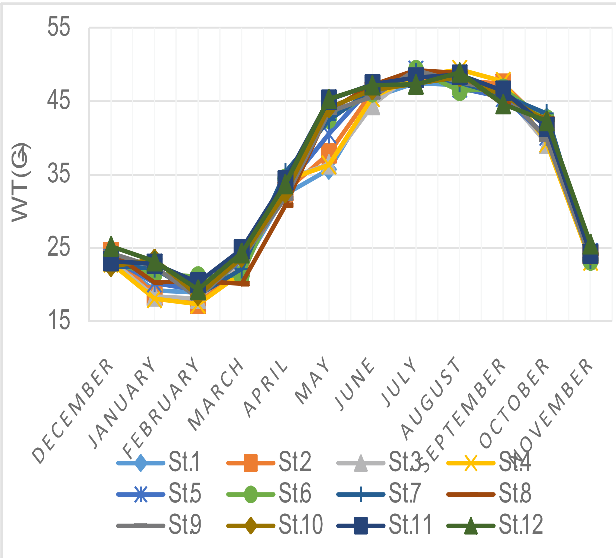


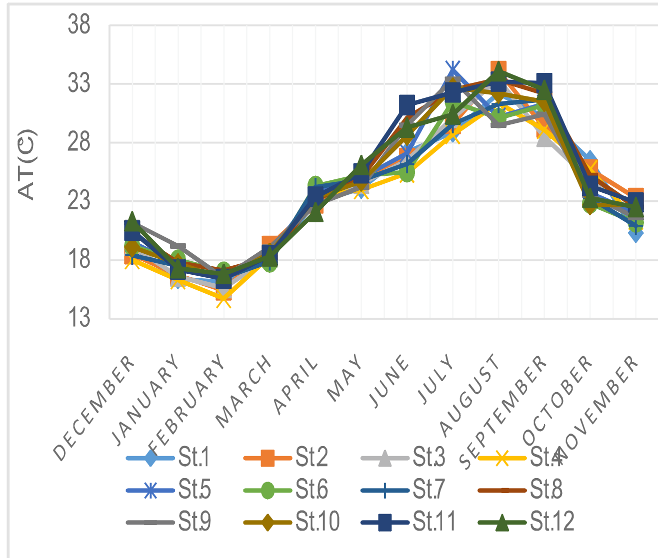
Fig. 1. Map of Shatt Al-Arab River showing the sampling stations

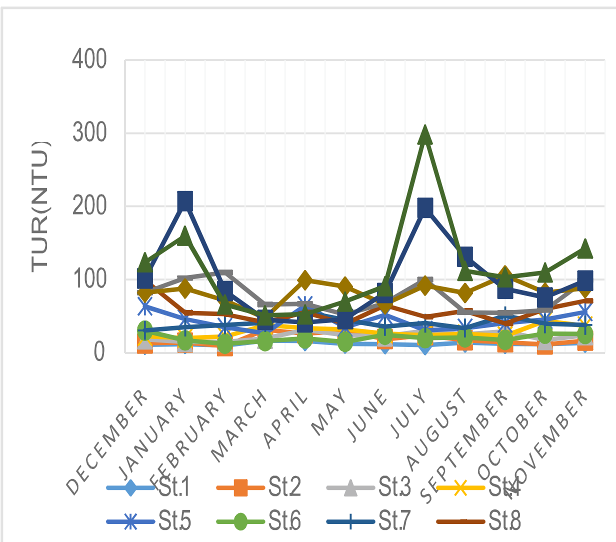
chemical, and biological properties. Significant differences were observed among seasons, the highest temperature was during the summer months and the lowest during the winter (14.7-34.2C°). Light penetration, depth, and total suspended solids (TSS) are inversely related to turbidity and degree of shading. The minimum light penetration of 35 cm was in August at station 5, due to the reduction in the discharge rates with the high temperatures and the increase in the concentration of pollutants that helped the growth of plankton, which works to reduce the penetration of light in the southern stations. Light penetration was low due to the large quantities of sediment discharges into the Shatt Al-Arab River. Moreover, oil pollution came from the Abadan oil refinery, and the River is narrowing at station 9 with the increase in ship activities. The upper limit of 95 cm was recorded at station 8 in March. It may be due to the role of aquatic plants play in increasing the transparency of water by filtering suspended materials and reducing the speed of water flow, which leads to the sedimentation of most suspended materials, which led to a rise in light penetration during the spring months (Moyel and Hussain 2015). The average values of turbidity ranged between 8.97 and 298.54 NTU, Stations 9-12 showed high values of turbidity during July as a result of low drainage rates from The Tigris, Euphrates, and Karun Rivers, with high temperatures and increased evaporation, which caused the invasion of a salty tide from the Arabian Gulf, in addition to large quantities of sewage waste from surrounding areas, movement of boats and ships and fishing. The current study has shown that the Shatt al-Arab River contains high turbid water that exceeds the permissible value (5 NTU) in aquatic ecosystems. Shatt Al-Arab River is also one of the rivers loaded with suspended matter. It ranged between 14.98 and 141.65 mg L^{-1}.

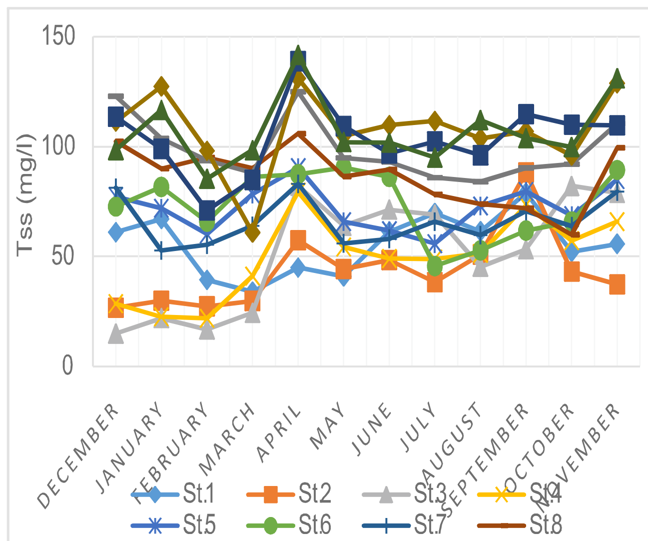
The high TSS in April may be due to rain and increased wind speed, which causes an increase in water mixing and an increase in suspended materials. The decrease in the suspended matter in March and February is due to plant infiltration and sedimentation of most suspended materials (Hillebrand et al 2018 (Table 2). Dissolved oxygen (DO) was used as a primary parameter for monitoring water quality and ranged between 5.1-9.8 mg L^{-1}. All stations showed increased DO levels during the winter and a decline during the summer. This was due to the inverse relationship of DO with temperature, where cold weather reduces the activity of decomposition of organic materials, in addition to rain, wind, and tidal movement that increases the movement and mixing of water. In summer, the high temperature leads to decreased DO values due to lower solubility of most gases, increased evaporation, lower water levels, and higher degradation activities (Bhateria and Jain 2016). This was clear in stations 5 and 6, exposed to excessive organic pollution from Basra city (Al-Lami et al 2014). The decrease in the value of DO in the southern parts may be due to the high salinity that reduces the levels of DO and the pollution at station 9 that comes from the Abadan oil refinery. However, the minimum DO values recorded in the current study were within the values previously recorded in the Shatt al-Arab River. The electrical conductivity EC ranged between 1.62 and 10.15 mS cm^{-1}, the EC is affected by several factors such as the amount of fresh water, the temperature, and the evaporation process, the amount of rain, progress of the extent of the salt tongue from the Arabian Gulf, as well as the quality of the soil through which the water passes. In addition to electric plants power that uses large quantities of water for cooling purposes, which results in a high concentration of salts due to evaporation, wastewater and urban runoff, agricultural and industrial wastewater, and chemicals used in the water treatment process (Al-Aboodi 2016). The EC values increased gradually from the source (station 1) to the downstream (station 12) during most of the study period, where a positive relationship was found between temperature and EC(r=0.8).

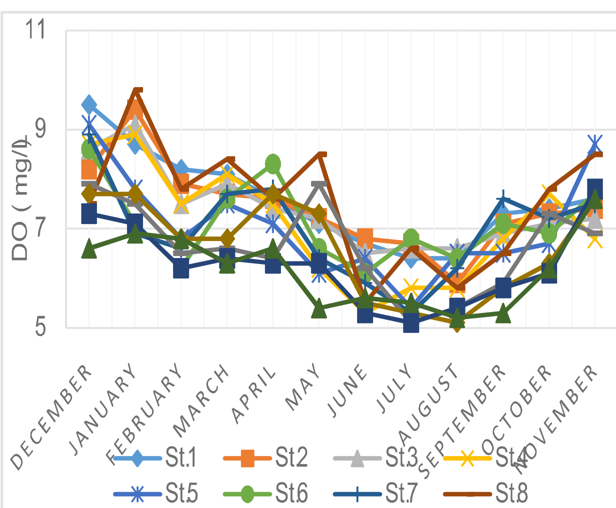
The pH ranges from 7.2 to 8.5, where the pH values were within the alkaline side of all stations during the study period, which is a feature of southern Iraq's waters because of the Iraqi lands) The high pH values in the summer season may result from higher temperatures and increased evaporation. Thus, the concentration of salts increases. A slight decrease in the pH values during the spring season can be attributed to the decomposition of the organic matter, leading to an increase in the concentration of carbon dioxide (Zang et al 2018). Figure 2 showed that the lowest levels of the total alkalinity value were in station 3, which reached 85.43 mg.L^{-1} during November, and the highest of 190.02 mg.L^{-1} was in station12 during June showed significant differences among stations and seasons. This may be due to the difference in the sites as well as human activities, increased in the summer in most study sites due to the higher productivity, and decreased in the winter due to the consumption of free carbon dioxide by the primary organisms and the decomposition of bicarbonate. The current results fall within the specified values for natural water, ranging from (20-200) mg.L^{-1} (APHA 2012). The water of the Shatt al-Arab River is considered very hard water (hardness> 181), and observed that there is a positive correlation between hardness and salinity, recorded the lowest average value of total hardness of 489.21 mg in station2 during June, while the highest average were 3050.6 mg.L^{-1} recorded in station 12 during July. The values of calcium levels ranged between 59.66 mg.L^{-1} at station1 during the April, and reaching its highest value in station 12

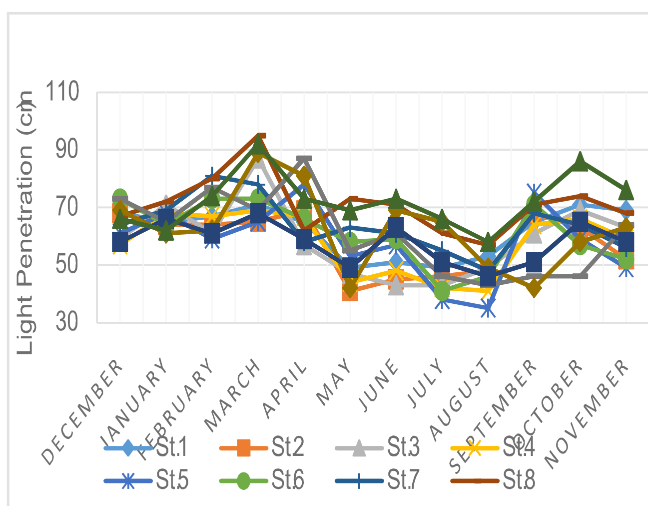

WT(C)
55
45
35
25
15
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St.2 St.3 St.4
St.5 St.6 St.7 St.8
St.9 St.10 St.11 St.12

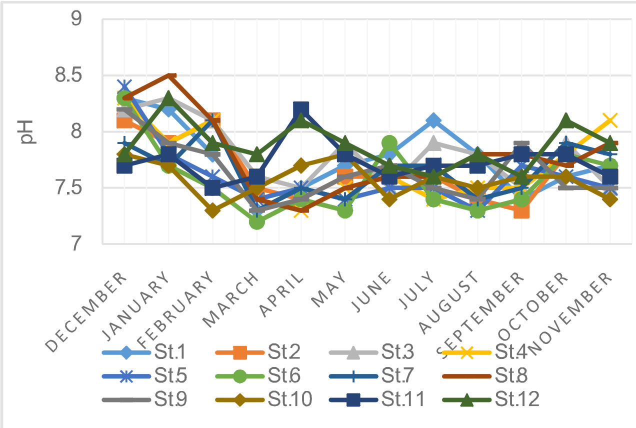

AT(C)
38
33
28
23
18
13
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St.2 St.3 St.4
St.5 St.6 St.7 St.8
St.9 St.10 St.11 St.12

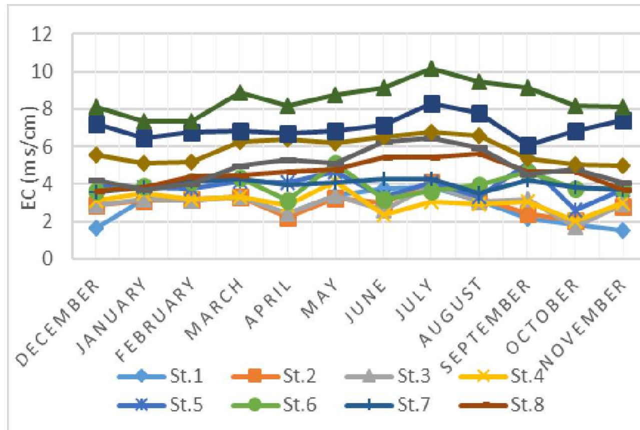

TUR(NTU)
400
300
200
100
0
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St.2 St.3 St.4
St.5 St.6 St.7 St.8

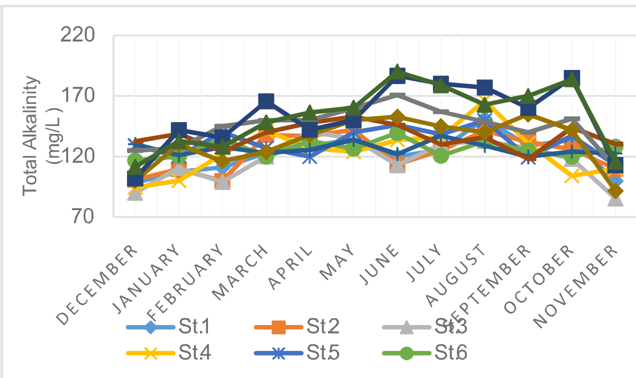

Tss (mg/l)
150
100
50
0
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St.2 St.3 St.4
St.5 St.6 St.7 St.8

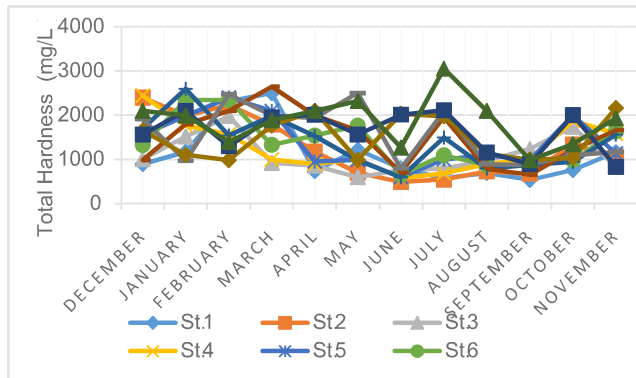

DO (mg/l)
11
9
7
5
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St.2 St.3 St.4
St.5 St.6 St.7 St.8

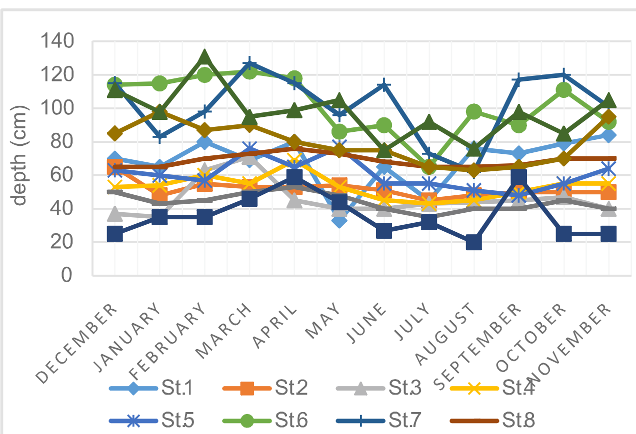

Light Penetration (cm)
110
90
70
50
30
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St.2 St.3 St.4
St.5 St.6 St.7 St.8

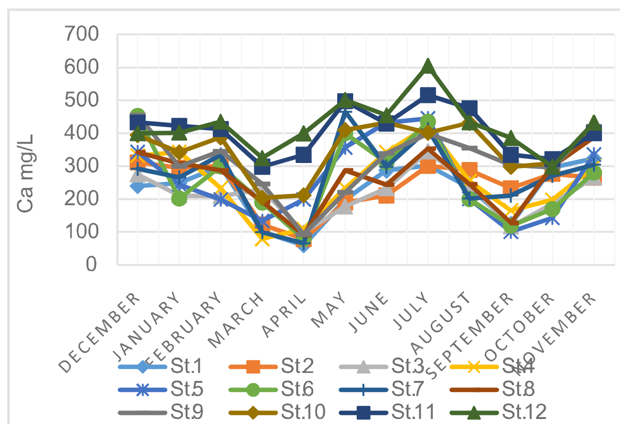

pH
9
8.5
8
7.5
7
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St2 St3 St.4
St.5 St.6 St.7 St.8
St.9 St.10 St.11 St.12

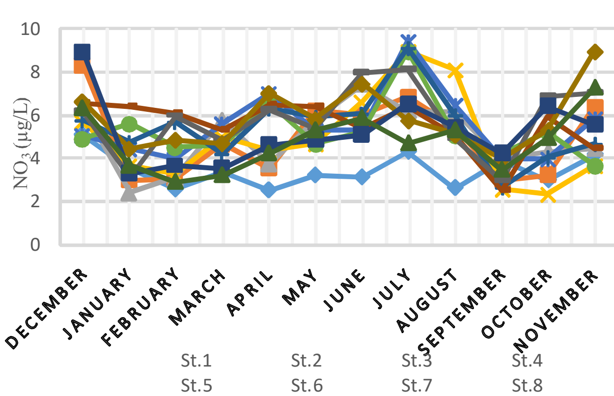

EC (m s/cm)
12
10
8
6
4
2
0
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St.2 St.3 St.4
St.5 St.6 St.7 St.8

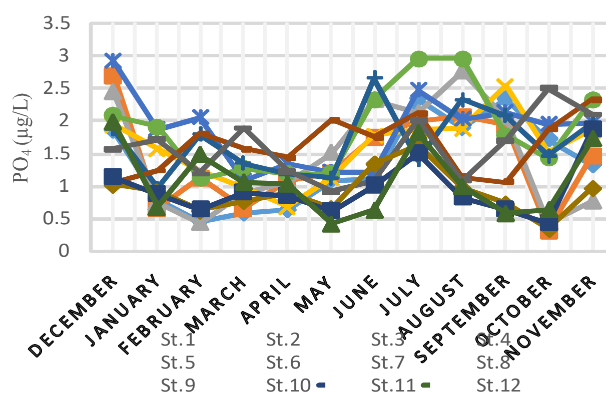

Total Alkalinity (mg/L)
220
170
120
70
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St2 St3
St4 St5 St6


Total Hardness (mg/L
4000
3000
2000
1000
0
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St2 St3
St4 St5 St6


depth (cm)
140
120
100
80
60
40
20
0
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St2 St3 St4
St5 St6 St7 St8


Ca mg/L
700
600
500
400
300
200
100
0
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St2 St3 St4
St5 St6 St7 St8
St9 St.10 St.11 St.12


NO_3 (µg/L)
10
8
6
4
2
0
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St.2 St.3 St.4
St.5 St.6 St.7 St.8


PO_4 (µg/L)
3.5
3
2.5
2
1.5
1
0.5
0
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER
St.1 St.2 St.3 St.4
St.5 St.6 St.7 St.8
St.9 St.10 St.11 St.12

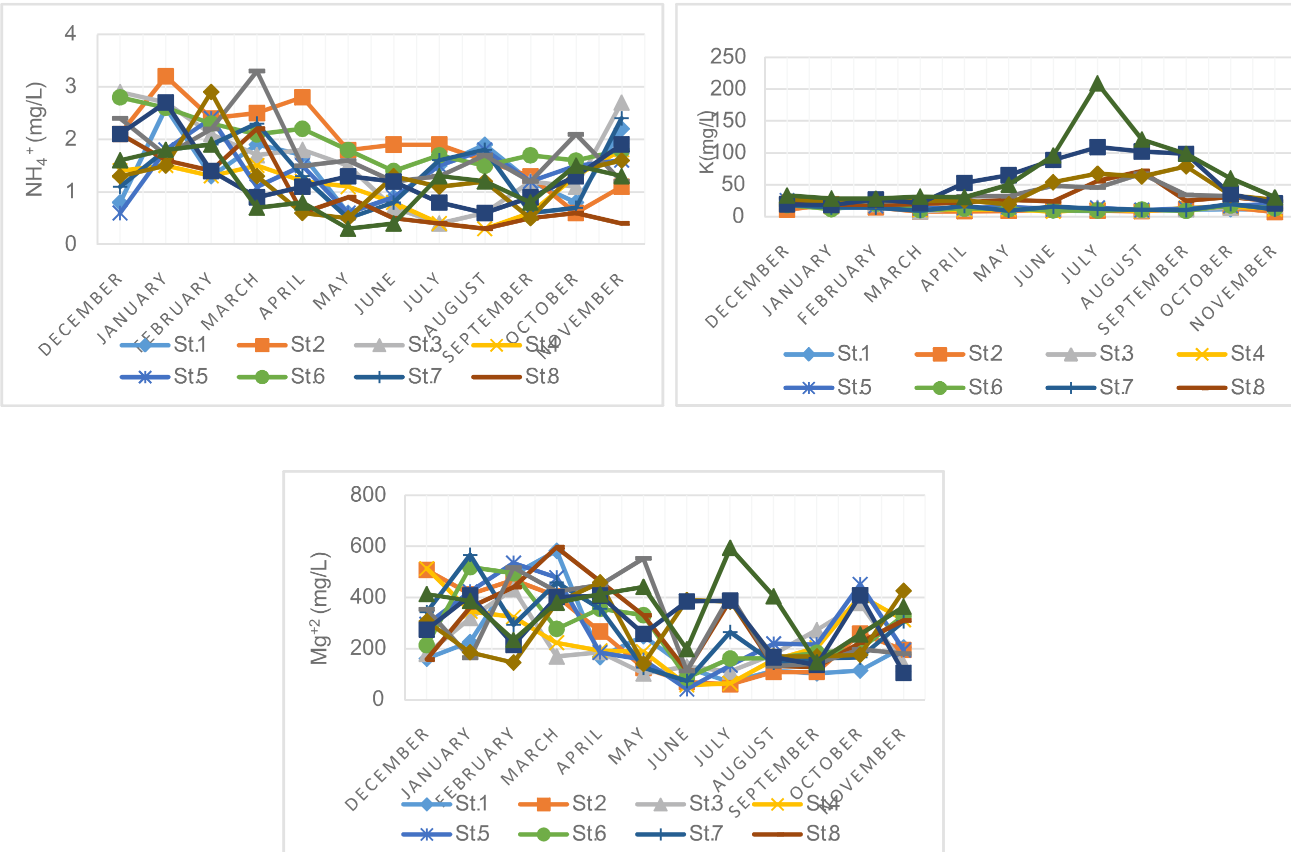


Fig. 2. The spatial and temporal variation of the twelve stations along the Shatt al-Arab River

Table 2. Water quality parameters and seasonal variation with comparative guidelines

Parameters	Unit	Range	Guideline drinking water* (WHO 2011)	Guideline aquatic life** (CCME 2007)
WT	C°	14.7 - 34.2	NS	10 - 35
AT	C°	17.3 - 49.3		
pH		7.2 - 8.5	6.5-8.5	6.5 – 9
EC	$mS.cm^{-1}$	1.62 - 10.15	2.5	5
Light Penetration Secchi disc (SD)	cm	35 - 95		
Turbidity (TUR)	NTU	8.97 - 298.54	<5	> 45
Depth	cm	20 - 131		
Total Suspended solids (TSS)	$mg.L^{-1}$	14.98-141.65		
Dissolved Oxygen DO	$mg.L^{-1}$	5.1 - 9.8	>5	>5
Total Alkalinity (TA) $CaCO_3$	$mg.L^{-1}$	89.99 - 190.02	NS	20-200
Total Hardness (TH) $CaCO_3$	$mg.L^{-1}$	489.21- 3050.6	500	500
Ca^{+2}	$mg.L^{-1}$	59.66 - 605	<150	NS
Mg^{+2}	$mg.L^{-1}$	40.66 - 597.11	<100	NS
K^{+}	$mg.L^{-1}$	6.7415 - 209.03	NS	NS
NO_3	$mg.L^{-1}$	2.32 - 9.42	11.000	2900
NH_4^{+}	$mg.L^{-1}$	0.3 - 3.3	1235 (μg/l)	187-473 (μg/l)
PO_4^{-}	$mg.L^{-1}$	0.31 - 2.95	NS	0.04

* World Health Organization (WHO) guideline recommended for drinking water and Iraqi guideline recommended for drinking water.
**Aquatic life: Iraqi standard for the protection general of water resources; NTU: Nephelometric turbidity unit, $meq.L^{-1}$: Milliequivalent per liter; NS: Not specified

during July 2020, which was 605 mg L^{-1}. The magnesium recorded the lowest average values of 40.66 mg.L^{-1} in station 5 during June, while station12 recorded the highest average values of 597.119 mg.L^{-1} during July (Fig. 2). A decrease in magnesium and calcium levels in the water column resulted from bioaccumulation and sedimentation at the bottom, the colloidal deposits on the bottom adsorb Ca^{+2} and Mg^{+2} ions (bha et al 2014, Potasznik and Szymczyk 2015). The highest magnesium concentration was recorded during the summer, this may be due to magnesium salts addition by plants and other organisms that decompose into the water column. The concentrations of total hardness, calcium and magnesium rise during the winter season in some stations due to rainfall that has added dust particles in the atmosphere or because of what is washed away by water and erosion resulting from the surrounding lands. Stations 11 and 12 were affected by the progress of the extent of the salt tongue from the Arabian Gulf, which works to raise the values of total hardness, calcium, and magnesium with high salinity and the agricultural and household wastes. The ion concentrations (Ca^{+2} and Mg^{+2}) in the Shatt al-Arab River exceeded the permissible limits. The potassium values in this study were within the range recorded in other studies in the Shatt al-Arab River, the rates of potassium ion values increased to reach their maximum of 209.03 mg.L^{-1} during July at the station12, while the lowest values were measured at Station 2 during November (6.7415 mg.L^{-1}). The Shatt al-Arab' River southern stations recorded an increase in cations' concentration, resulting from the salt tide from the Arabian Gulf and sewage water, Breeding animal areas, and agricultural areas. Skowron et al (2018) showed that the highest potassium levels are directly below the Lublin wastewater treatment plant's outlet. Moreover, the K + contents in water in agricultural and animal production areas are much lower than wastewater points. (Yadata 2014) noted the high potassium ion concentration in Achane River due to fertilizers used for soil fertility, which mixes with river water. The values of nutrients (Ammonium, nitrates, and phosphates) fluctuated during the months of the current study, the lowest levels of ammonium NH_4^+ concentrations were 0.3 mg.L^{-1} at station12 during May, and the rates increased to reach 3.3 mg.L^{-1} at the station 9 during the March. The nitrates NO_3^- ranged between the lowest values in station 4 in October, reaching 2.32 mg.L^{-1}, while the highest values reached 9.42 mg.L^{-1} in station 5 in July. The phosphates ranged between 0.31 mg.L^{-1}at station 2 in October as a minimum and 2.95 mg.L^{-1} in station 6 in July as a maximum (Fig. 2). The most of the Shatt al-Arab river stream stations showed higher nitrogen compounds than the upstream stations because they are more susceptible to pollutants resulting from the Basra city center's household sewage. In addition, climatic changes and a decrease in water entering the River have led to a change in nitrogen compounds concentrations. In addition, nitrate values increased in some stations during spring 2020. The reason may be due to the fall of rain that carries dissolved salts and nitrogen fertilizers, sewage and industrial water from neighboring agricultural lands into the water, or the decomposition processes of dead organisms' bodies from plants and animals. Ishaq and Khan (2013) confirmed nutrients (nitrates and phosphates) changed with months and seasons. Many factors such as floods, erosion of agricultural lands, fertilizers, and organic household waste control nitrate and phosphate levels. The ammonium ion concentrations were low throughout the study period. There were significant differences among months and stations and increased in some stations because of the high number of detergents and organic materials in the wastewater. The fertilizers washed away from agricultural lands and the Branch Rivers that flow into the Shatt al-Arab River. Some stations have recorded a decrease in ammonium ion values due to ammonia's oxidation to nitrite and nitrate with an abundance of oxygen. The results were similar to previous studies on the Shatt al-Arab River (AL-Jorany et al 2011). Humans contribute to raising the phosphorous concentration in rivers through the use of detergents and phosphate fertilizers (Hébert et al 2019). The concentration of phosphorus increased in the central stations of the Shatt al-Arab River as a result of the disposal of liquid industrial waste, sewage water, and fertilizers from the farms. An increase in the concentrations was observed in station 8 because of the plant's proximity to the harmful effect of the discharge of the fertilizer plant in the River. Most of the low values were recorded at stations 11-12 and may be due to mixing with seawater or due to the high turbidity of the water in these stations, which leads to the adsorption and precipitation of phosphorus, Low phosphorus concentrations, at station 1 far from the effluent discharge points, maybe due to the ability to self-purify the River, the statistical analysis of nutrients showed that there were significant differences among months and stations. Some stations did not exceed the limits allowed by the specifications. Still, the most significant number of examined stations exceeded the range limits by WHO (2011) in addition to the aquatic life criteria recommended by CCME (2007). Al-Aboodi (2016) mentioned that the WQI of the Shatt al-Arab River is under very poor quality during the summer season. It ranges from very poor quality to unsuitable for drinking purposes during the winter season.

CONCLUSIONS

The Shatt al-Arab River is affected by climate change and drought, the decreasing water supplies, the extent of the salt tongue coming from the Arabian Gulf, and the increasing Turbidity, NO_3, and PO_4. Nutrients and salinity are the most diverse variables in the Shatt al-Arab River. The low level of the Tigris and Euphrates River that feeds the Shatt al-Arab River has caused small amounts of water to be discharged, and the Karun River water coming from the Iranian that feeds the freshwater to the Shatt al-Arab is one of the main reasons for increasing the concentration of salt in the Shatt al-Arab River water. In addition to pollution of the River's water, sanitation, agricultural and industrial, it led to the deterioration of the Shatt al-Arab River's ecosystem with its various components (soil, water, and plants).

REFERENCES

Al-Aboodi AH 2016. Estimation of monthly mean reference evapotranspiration using gene expression programming. *Kufa Journal of Engineering* **8**(1): 37-50.

Al-Asadi SAR 2017. The future of freshwater in Shatt Al-Arab River (Southern Iraq). *Journal of Geography and Geology* **9**(2): 24-38.

Al-Asadi WMT 2014**.** Study the effect of some environmental variables on the abundance and distribution of submerged aquatic plants in Marsh al-Hammar and the Shatt al-Arab. University of Basrah, College of Science, Department of Biology. *Basra Journal of Science* **32**(1): 20-42.

Al-Lami AMA, Abbas ZR and Alshammary AG 2020. Study of water pollution problem in Basra city of Iraq: a case study. *Plant Archives* **20**(1): 2274-2276

Al-Tememi MK, Hussein MA, Khaleefa UQ, Ghalib HB, Al-Mayah AM and Ruhmah AJ 2015. The salts diffusion between East Hammar marsh area and Shatt Al-Arab River Northern Basra City. *Marsh Bulletin* **10**(1): 36-45.

Bha TSA, Mera JG, Yaseen S and Pandi TAK 2014. Statistical assessment of water quality parameters for pollution source identification in sukhnag stream: an inflow stream of Lake Wular (Ramsar Site), Kashmir Himalaya. *Journal of Ecosystems* **1**(1): 1-18.

Bhateria R and Jain D 2016. Water quality assessment of lake water: a review. *Sustainable Water Resource* Management **2**(1): 161-173.

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CCME (Canadian Council of Ministers of the Environment) 2007. For the protection of aquatic life 2007. In: *Canadian Environmental Quality Guidelines, 1999,* Canadian Council of Ministers of the Environment, 1999, Winnipeg

Everard M 2019. A socio-ecological framework supporting catchment-scale water resource stewardship. *Environmental science and policy* **91**(1): 50-59.

Hébert MP, Fugère V and Gonzalez A 2019. The overlooked impact of rising glyphosate use on phosphorus loading in agricultural watersheds. *Frontiers in Ecology and the Environment* **17**(1): 48-56.

Hillebrand G, Hardenbicker P, Fischer H, Otto W and Vollmer S 2018. Dynamics of total suspended matter and phytoplankton loads in the River Elbe. *Journal of Soils and Sediments* **18**(10): 3104-3113.

Humphries P, Keckeis H and Finlayson B 2014. The river wave concept: Integrating river ecosystem models. *Bioscience* **64**(10): 870-882.

Ishaq F and Khan A 2013. Water Res. diversity pattern of macrozoobenthos and their relation with qualitative characteristics of river Yamuna in Doon Valley Uttarakhand. American-Eurasian. *Journal of Toxicological Science*s **5**(1): 20-29

Moyel MS and Hussain NA 2015. Water quality assessment of the Shatt al-Arab River, Southern Iraq. *Journal of Coastal Life Medicine* **3**(6): 459-465.

Potasznik A and Szymczyk S 2015. Magnesium and calcium concentrations in the surface water and bottom deposits of a river-lake system. *Journal of Elementology* **20**(3): 677-692.

Schoonees T, Mancheño AG, Scheres B, Bouma TJ, Silva R, Schlurmann T and Schüttrumpf H 2019. Hard structures for coastal protection, towards greener designs. *Estuaries and Coasts* **42**(7): 1709-1729.

Skowron P, Skowronska M, Bronowicka-Mielniczuk U and Filipek T 2018. Anthropogenic sources of potassium in surface water: The case study of the Bystrzyca river catchment, *Pol and Agriculture Ecosystems and Environment* **265**(1)**:** 454-460

Tepe Y and Aydin H 2017. Water quality assessment of an urban water, Batlama Creek (Giresun), Turkey by applying multivariate statistical techniques. *Fresenius Environ Bull* **26**(1): 6413-6420.

WHO (World Health Organization) 2011. Guidelines for drinking water quality, 4th edt. WHO, Geneva? ISBN 978-92-4-154815-1

Yadata D 2014. Determination of the Concentration of K^{+1}, Na^{+1} and Fe^{+2} in Achane and Shay River a Case of Tepi Town. *Universal Journal of Chemistry* **2**(4): 59-63.