Indicate the pollution extent at Shatt Al-Arab waters by water quality index (Canadian model)

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Abstract

The assessment of water quality is an important matter in the management of water resources, by the great pollution that this water encounters. This study was conducted to evaluate the water quality of Shatt Al-Arab, on the basis of chemical, physical and qualitative characteristics taken for the river, indication of the extent of pollution in its waters, according to the standard standards approved in the Iraqi Rivers Protection System from Pollution No. 25 of 1967, water quality index application (Canadian model (CCME). Sixteen stations were selected on Shatt Al-Arab from north to south, from October 2021-September 2022, the measurements were monthly. The study showed that there are seasonal and regional variations, depending on the time and place of sampling. The contrast was clear between the northern part and the southern part of the river, between the summer season compared to the winter season. The highest recorded value of the index (PWQI) was in the northern part of the river represented by the stations (Al-Qurna, Al-Hartha and Paper Mill) during the winter season, while the lowest values were recorded in the stations located in the southern part of the river, represented by stations (fifth and sixteenth (Al-Faw and Al-Naqaa). The index values were equal (22) during the summer semester, as for the annual average, the first and second stations (Al-Qurna and Paper Mill) recorded the highest value, which was (32), as for the lowest value recorded as an annual average, it is in the fifteenth station (Al-Faw), as the value (20) was recorded, and with these low values during the study seasons (summer-winter) and as an annual average, then all values fall within the category (Poor), that was, the water is weak and always exposed to pollution, and it is far from ideal at all times, because of the high concentration of dissolved salts, in addition to the waste of agricultural, industrial and domestic waste and its impact on that major deterioration.

Keywords: *pollution, Shatt Al-Arab, water quality index (Canadian model).*

INTRODUCTION

Water resources top the list of priorities in human life and ecosystems on Earth, the proportion of fresh water available for direct human use does not exceed 0.768% of the total volume of water, the amount of 548,000,000 billion cubic meters on the surface of the earth, responsible for constantly feeding fresh water bodies (Al-Mahmoud, 2020). Climatic changes all over the world in general and in the study area in particular had a great impact on these water resources, the world is witnessing of a large population increase, and what this increase results in depleting large quantities of water, the discarded pollutants of all kinds, whether agricultural, human or industrial (Ewaid, 2018). Wastewater and the high levels of antibiotics these pollutants contain (Mayada et al., 2022). Substances that are toxic to plants and animals, especially when they are present in high concentrations that exceed the required need, remains of wrecked ships in the river due to geomorphological changes in the waterways, as pollutant aggregation areas and its impact on water quality (Audai & Thamer, 2022). The scarcity of fresh water, salinity and pollutants has become one of the most important problems, led to poor water quality and changes in the environment of the ecosystem, surface water quality has become a very sensitive and critical issue for the economic and social development, well-being and long-term sustainability of the environment, concern increased over how to find solutions to get out of these problems, new methods have been adopted in water management, including continuous and regular monitoring of water resources and their evaluation for different uses (Ewaid et al., 2020). A study conducted by Chabuk (2020) showed that one of the methods that can be used to preserve surface water in Iraq, monitoring sources of pollution and trying to prevent or reduce their effects, or in the worst case, finding suitable methods that can be used to invest polluted water, to ensure the removal or reduction of pollutants as much as possible to produce water quality that can meet the standards for irrigation and industrial uses, so consider the Water Quality Index (WQI). The preferred scientific method to solve these problems, as it uses many variables of water quality, formulated in a numerical form that includes the integrated impact of these variables on water quality, by water can be qualitatively classified for various uses within specific categories and in a simple scientific way, this evidence is based on the nature of the change in water quality during short and long-term periods, taking into account the nature of the river in terms of its degree of pollution and purity, this guide is an important system for water quality management, by defining the nature of use of the water resource and specifying the required treatment method for all activities, as the concept of the guide is based on a comparison between a group of water quality variables and the permissible limits according to standards and specifications, which refers to a huge volume of data or a set of complex data, which is collected from the water body and then scales the index between (0-100), whereas, a higher value explains good water quality, and a lower value indicates poor water quality (Tao, 2019).

Since the specifications of the water quality of the Shatt al-Arab are affected by the quality of the water coming to it from the sea and the phenomenon of tides in the river basin, in addition to the river's exposure to pollutants resulting from the dumping of household, agricultural, sanitary and industrial waste directly into the river, which negatively affects the quality of the river's water, therefore, this study tended to achieve the following objectives:

1. Using the Water Quality Index (WQI), as an efficient way to summarize various data on water quality, displayed in quantitative terms, this makes it easier to know the temporal and spatial changes resulting from the impact of different sources on the water under study.

2. Applying the Water Quality Index (WQI), to assess the waters of the Shatt al-Arab and determine the extent of river pollution.

Material and Methods:

Study area description:

Figure 1: Map of water sample collection sites along the course of the Shatt al-Arab from Al-Qurna to Al-Faw.

Study area:

The Shatt Al-Arab was formed by the confluence of the Tigris and Euphrates rivers at Al-Qurna, north of Basra, extending in a southeastern direction, for about 204 km2, it empties into the northwest of the Arabian Gulf in the city of Al-Faw, as for at this time, it is an extension of the Tigris River only after it closed the Euphrates River in the city district, characterized by the presence of the tidal phenomena that occur half a day and which originate from the Arabian Gulf, there are several subsidiary rivers on both sides of the Shatt Al-Arab that were used as irrigation channels and these branches in the city, recently used as drains for sewage channels and industrial facilities built on them, which could affect the water quality in the Shatt Al-Arab basin.

The waters of the Shatt al-Arab are characterized by the presence of two main areas in the river, one of which is characterized by fresh water, located in the northern part of the river as a result of being affected by the fresh waters of the Tigris River, with salty water located south of the river affected by the salty tide waters from the Arabian Gulf and coinciding with the salinity coming from the Al-Hammar marsh through the Al-Mashab and Al-Salal rivers via the Al-Karmah river, which flows into the Shatt al-Arab, while there are two secondary transitional areas, one of which is the fresh water coming from the upper course of the river and mixed with the salty water from the bottom of the river, and the second is the salty water coming from the bottom of the river and mixed with the fresh water coming from the top of the river. The sources of fresh water for the Shatt al-Arab River were 38.1% from the Tigris River, 30.4% from the Euphrates River, 30.4% from the Karun River, and 8.8% from the Karkheh. The gradual increase in the extent of tides in the Shatt al-Arab River, due to the slope of the river from the north towards the south in the direction of the river at the location of Al-Faw and its source is the tides in the Gulf (Al-Asadi and Alhello, 2019).

Water sample collection (field work):

Surface water samples were collected from the Shatt al-Arab in the city of Basra at sixteen stations from the north to the south of the river, they were Al-Qurna, Paper Mill, Al-Hartha, Al-Najibiyah, Ports, Al-Ashar, Al-Baradiyah, Presidential Palaces, Al-Bahadriyah, Al-Muhaila, Abu Al-Khasib, Seyhan, Al-Siba, Al-Duwaib, Al-Faw and Al-Naq’a respectively, for a full year from 10/2021 to 9/2022, each month, according to Figure 1. The samples were placed in clean plastic containers with a capacity of (1 liter), stored in the refrigerator at a temperature of 4 degrees Celsius, to carry out the remaining required measurements of chemical and physical properties and the quality of heavy metal concentrations in the laboratories of the Soil Heights and Water Resources Department. The results are shown in Tables 1, 2, 3 and 4.

Laboratory work:

The chemical, physical, qualitative properties and heavy metal concentrations of the samples were estimated, taken from the waters of the Shatt al-Arab based on methods described in APHA (2017), which was the pH of water (pH) - electrical conductivity (E.C) - chloride Cl - nitrate NO3 - and heavy elements such as manganese, Mn, iron, Fe, zinc, Zn, lead, Pb, cadmium, Cd.

Statistical analysis:

The statistical analysis of the data was based on the statistical program (SPSS Ver.1.7) (Statistical Package for Social Science) and below the level of significance 0.05, and the Least Significant Difference Least (LSD) test (Al-Rawi and Khalaf Allah, 1980).

Table 1: Chemical, physical and qualitative properties and measured heavy elements for the studied stations (northern part of Shatt al-Arab).

St.	Months	PH	E.C ms/cm	Cl mg/l	NO3 mg/l	PO4 mg/l	NH4 mg/l	DO mg/l	BOD5 mg/l	Mn µg/l	Fe µg/l	Zn µg/l	Pb µg/l	Cd µg/l
Al-Qurna	October	7.8	1.6	424.9	0.6	0.7	3.6	3.9	3.9	43.0	3053.0	57.0	56.0	11.8
	November	7.8	1.8	448.0	0.5	0.7	4.4	3.9	3.9	61.0	3730.0	77.0	68.0	11.0
	December	7.9	1.6	431.7	0.5	0.7	3.0	3.5	3.5	58.0	2399.0	48.0	73.0	15.0
	January	7.9	1.3	336.9	0.6	0.5	2.8	3.3	3.3	33.0	4987.0	38.0	85.0	16.0
	February	8.4	1.2	340.2	2.6	0.5	2.7	3.1	3.1	39.0	6059.0	55.0	78.0	46.0
	March	8.2	3.4	683.9	2.4	0.5	2.8	3.6	3.6	48.0	2881.0	60.0	56.0	27.7
	April	8.3	4.4	1205.2	1.2	0.7	2.8	4.8	4.8	31.0	3412.0	116.0	57.0	23.0
	May	8.2	4.6	1223.6	0.9	2.5	3.3	6.0	6.0	31.5	2755.0	122.0	52.0	21.3
	June	8.3	4.8	1240.7	0.9	2.6	4.6	6.3	6.3	27.0	2831.0	161.0	67.0	19.4
	July	8.4	4.9	957.1	0.8	2.9	4.8	3.1	3.1	20.8	2793.0	232.0	118.6	17.7
	August	8.4	3.6	708.9	0.7	1.3	4.8	3.6	3.6	25.1	2330.8	301.2	230.2	17.0
	September	8.4	2.3	460.0	1.4	0.7	4.0	2.5	2.5	23.7	2205.8	270.7	228.6	16.1
	Mean	8.2	3.0	705.1	1.1	1.2	3.6	4.0	4.0	36.8	3286.4	128.2	97.4	20.2
Piper mill	October	8.0	2.0	566.2	0.5	0.7	3.7	3.1	3.1	17.0	3715.0	43.0	50.0	11.8
	November	7.9	1.9	451.9	0.5	0.7	4.8	3.1	3.1	74.0	3840.0	62.0	68.0	24.0
	December	8.0	1.8	443.4	0.5	0.7	3.4	3.1	3.1	33.0	3200.0	37.0	63.0	25.0
	January	7.8	1.4	396.2	0.5	0.4	3.2	3.0	3.0	25.0	4710.0	47.0	66.0	24.0
	February	8.5	1.3	317.2	2.3	0.4	3.0	2.9	2.9	22.0	5541.0	62.0	63.4	43.0
	March	8.2	3.5	655.9	2.2	0.4	3.1	2.9	2.9	43.0	3569.0	67.0	66.2	44.0
	April	8.3	4.2	974.8	1.2	0.6	3.3	4.5	4.5	30.0	1714.0	112.0	66.0	17.0
	May	8.2	4.9	1099.7	1.0	1.4	3.6	5.9	5.9	31.0	3025.0	121.0	73.0	11.3
	June	8.5	5.0	1132.8	0.9	1.6	4.0	6.3	6.3	31.1	2231.0	134.0	72.0	11.2
	July	8.4	3.3	526.5	0.3	2.1	6.2	2.4	2.4	20.8	3495.0	130.0	116.5	11.4
	August	8.5	4.9	815.4	0.3	1.1	6.2	3.3	3.3	25.1	2364.2	317.0	209.5	13.3
	September	8.4	3.0	636.0	0.9	0.7	5.7	2.2	2.2	24.9	1539.2	289.5	202.7	11.9
	Mean	8.2	3.1	668.0	0.9	0.9	4.2	3.6	3.6	31.4	3245.3	118.5	93.0	20.7
Al-Hartha	October	7.9	2.1	571.2	0.5	0.7	3.8	8.8	3.9	40.0	3721.0	56.0	60.0	11.9
	November	7.9	1.9	455.4	0.5	0.7	4.8	9.0	4.1	76.0	3920.0	75.0	73.0	17.0
	December	8.0	1.8	450.2	0.5	0.7	3.5	8.5	4.1	55.0	2271.0	39.0	59.0	16.0
	January	7.9	1.9	574.4	0.5	1.1	3.4	8.5	3.3	36.0	6727.0	62.0	45.0	16.0
	February	8.3	1.8	533.9	2.3	0.7	3.3	8.9	3.1	35.0	6244.0	71.0	64.0	16.3
	March	8.4	4.8	1152.4	2.2	0.7	3.3	8.7	3.8	33.0	3876.0	76.0	72.0	16.4
	April	8.5	5.1	1347.6	2.0	0.7	3.4	8.5	3.9	32.0	2270.0	76.0	64.0	17.0
	May	8.2	5.4	1365.1	1.8	2.1	3.7	7.1	4.9	45.0	1782.0	58.0	84.0	10.3

	June	8.1	5.8	1417.2	1.2	3.1	5.3	6.9	6.5	35.0	7582.0	50.0	175.0	10.4
	July	8.5	5.6	1240.4	1.0	3.4	6.8	6.6	5.8	21.0	2123.0	134.0	180.6	17.7
	August	8.6	11.7	2838.2	1.0	2.3	6.8	3.5	2.9	29.9	2022.5	328.0	288.9	18.7
	September	8.2	8.5	2126.0	0.8	0.6	6.2	6.9	2.4	27.9	1814.2	296.2	266.7	16.5
	Mean	8.2	4.7	1172.7	1.2	1.4	4.5	7.7	4.0	38.8	3696.1	109.9	119.4	15.3
Al-Najibia	October	7.9	2.3	627.6	0.7	0.9	4.1	10.0	4.5	23.0	4100.0	23.0	81.0	10.5
	November	7.9	2.5	539.6	0.5	0.9	5.3	10.0	4.5	72.0	4150.0	45.0	70.0	17.0
	December	8.1	2.3	524.3	0.9	0.7	4.7	10.1	4.1	67.0	2580.0	44.0	72.0	13.0
	January	8.0	2.0	591.4	0.9	0.6	4.4	10.9	4.1	43.0	5244.0	50.0	53.0	20.0
	February	8.2	1.7	472.1	3.6	0.6	4.3	11.4	3.2	62.0	5214.0	57.0	77.0	74.0
	March	8.3	5.3	1062.9	3.4	0.6	4.4	10.4	6.2	28.0	3046.0	60.0	64.0	78.0
	April	8.3	5.1	1152.0	2.1	0.7	4.6	9.0	6.2	31.0	2695.0	70.0	60.0	60.0
	May	8.1	5.3	1223.1	1.8	1.7	4.8	7.4	7.1	30.8	1965.0	37.0	62.0	50.0
	June	8.1	5.5	1243.9	2.2	2.8	6.3	6.7	5.1	30.5	2188.0	36.0	107.0	49.2
	July	8.3	5.8	1004.8	0.9	2.9	7.9	6.8	4.5	33.0	3181.0	112.0	182.2	25.1
	August	8.6	10.0	2482.9	0.9	1.2	7.9	5.5	3.5	22.7	1655.8	305.7	288.9	20.8
	September	8.2	9.4	2512.5	0.9	0.7	7.3	6.7	4.3	22.2	2372.5	300.9	277.9	18.7
	Mean	8.2	4.8	1119.8	1.6	1.2	5.5	8.7	4.8	38.8	3199.3	95.1	116.3	36.4

Table 2: Chemical, physical and qualitative properties and measured heavy elements for the studied stations (middle part of Shatt Al-Arab).

St.	Months	**PH**	**E.C ms/cm**	**Cl mg/l**	**NO3 mg/l**	**PO4 mg/l**	**NH4 mg/l**	**DO mg/l**	**BOD5 mg/l**	**Mn µg/l**	**Fe µg/ l**	**Zn µg/ l**	**Pb µg/ l**	**Cd µg/l**
Ports	October	7.9	2.5	688.3	0.8	1.0	4.3	10.1	3.7	23.0	3280.0	20.0	43.0	11.8
	November	7.9	2.7	598.5	0.7	1.0	5.6	9.9	3.8	69.0	4330.0	94.0	68.0	15.0
	December	8.0	2.5	560.2	0.8	0.9	4.9	10.1	3.5	52.0	3209.0	44.0	65.0	17.0
	January	7.9	2.3	638.5	0.8	0.9	4.6	11.0	3.2	37.0	5880.0	52.0	40.0	25.0
	February	8.5	1.8	494.9	3.1	0.9	4.5	10.9	5.6	45.0	6867.0	65.0	53.4	62.0
	March	8.4	4.8	1044.8	2.9	0.9	4.6	9.1	5.8	48.0	4827.0	67.0	54.2	71.0
	April	8.4	4.5	1010.3	2.2	0.9	4.6	9.0	5.1	31.0	2541.0	47.0	57.0	71.1
	May	8.0	5.5	1239.7	1.9	2.0	4.8	7.1	6.1	31.9	3757.0	40.0	73.4	46.4
	June	8.5	5.5	1245.4	2.1	2.7	6.3	6.6	6.0	31.5	2353.0	60.0	71.4	77.9
	July	8.4	6.1	1409.4	0.8	3.4	8.5	6.7	4.0	26.9	3505.0	161.0	188.6	55.6
	August	8.5	9.0	2305.0	0.8	1.2	8.5	5.6	3.7	20.4	1855.3	315.1	309.8	50.9
	September	8.4	7.9	2158.2	0.9	0.7	8.1	6.7	2.4	30.9	1664.2	311.5	297.0	37.5
	Mean	8.2	4.6	1116.1	1.5	1.4	5.8	8.6	4.4	37.2	3672.4	106.4	110.1	45.1
Al-Ashar	October	7.8	3.2	848.5	1.1	1.0	3.9	10.1	3.4	23.0	4480.0	55.0	62.0	14.0
	November	7.8	3.6	861.9	0.9	1.0	6.0	10.1	3.5	74.0	3990.0	59.0	61.0	16.0
	December	8.2	3.2	779.2	0.9	0.7	4.6	10.2	3.0	61.0	2240.0	38.0	68.0	24.0
	January	8.0	2.5	668.4	1.0	0.6	4.5	11.2	3.0	31.0	5658.0	54.0	35.0	22.0
	February	8.4	2.2	542.3	3.1	0.6	4.5	11.7	2.9	38.0	3925.0	56.0	59.0	31.9
	March	8.4	4.8	1057.9	2.9	0.7	4.7	11.5	5.2	32.0	3347.0	66.0	91.2	71.0
	April	8.3	5.2	1099.4	2.2	0.7	4.7	9.1	5.3	31.0	3068.0	78.0	93.0	73.0
	May	8.0	5.5	1169.5	2.0	2.2	4.9	7.8	6.3	36.0	1710.0	51.0	92.4	77.3
	June	8.0	5.6	1175.5	1.6	2.7	6.9	6.7	6.1	37.0	2157.0	52.0	109.5	78.7
	July	8.3	6.5	1237.5	0.7	3.3	8.7	7.1	4.0	33.5	3117.0	166.0	202.6	80.7
	August	8.5	8.3	1807.7	0.7	1.2	8.7	5.7	4.8	32.2	2730.8	322.7	328.6	63.2
	September	8.4	9.5	2441.0	1.0	0.7	8.7	6.5	2.6	32.1	2189.2	316.1	308.6	54.3
	Mean	8.2	5.0	1140.7	1.5	1.3	5.9	9.0	4.2	38.4	3217.7	109.5	125.9	50.5
Al-Bradhia	October	7.9	3.6	1097.0	1.1	1.0	4.1	10.1	3.8	33.0	2878.0	28.0	49.0	21.3
	November	7.8	3.8	932.9	1.0	1.1	6.1	9.9	3.8	78.0	5010.0	66.0	65.0	17.0
	December	8.0	3.5	855.6	1.1	0.6	5.4	10.3	3.6	48.0	2490.0	25.0	66.0	17.0

	January	7.8	2.8	726.7	1.1	0.5	5.2	11.5	3.4	41.0	4784.0	57.0	45.0	16.0
	February	8.5	2.7	692.2	3.2	0.5	5.0	12.1	3.3	46.0	4531.0	60.0	55.0	53.0
	March	8.4	5.2	1312.9	3.2	0.5	5.2	11.8	4.7	28.0	2914.0	68.0	96.0	81.0
	April	8.4	5.8	1311.7	2.2	0.6	5.2	9.1	5.8	31.0	3500.0	82.0	92.0	87.0
	May	7.9	5.5	1329.4	1.9	2.9	5.5	7.9	6.6	39.1	2604.0	106.0	173.0	87.3
	June	8.0	6.0	1348.0	1.5	3.8	6.6	6.7	6.2	32.4	3026.0	89.0	225.0	90.7
	July	8.3	6.3	1411.8	0.8	4.3	9.3	6.6	4.6	29.8	4630.0	178.0	218.4	93.9
	August	8.6	13.3	3013.6	0.8	1.4	9.3	5.3	4.0	30.5	1797.5	362.3	330.7	90.1
	September	8.2	8.6	2010.2	1.0	0.8	9.1	6.6	2.1	30.3	1755.8	348.4	321.0	65.7
	Mean	8.2	5.6	1336.8	1.6	1.5	6.3	9.0	4.3	38.9	3326.7	122.5	144.7	60.0
Presidential palaces	October	7.9	3.7	1112.2	1.1	1.1	4.8	10.2	4.0	23.0	3071.0	44.0	43.0	10.5
	November	7.8	4.0	973.1	1.1	1.1	6.8	10.0	4.0	67.0	3200.0	112.0	62.0	17.0
	December	8.2	3.8	933.3	1.1	0.7	5.7	10.2	3.7	39.0	1902.0	33.0	61.0	13.0
	January	8.1	3.1	797.6	1.1	0.7	5.4	11.3	3.6	29.0	3734.0	58.0	61.0	17.0
	February	8.5	2.9	784.8	3.6	0.6	5.4	11.4	3.3	37.0	5910.0	64.0	80.5	57.0
	March	8.4	5.3	1188.5	3.5	0.7	5.4	10.8	4.6	47.0	3616.0	65.0	85.2	78.0
	April	8.4	5.8	1330.2	2.3	0.8	5.5	9.6	5.0	38.5	1948.0	83.0	63.0	77.0
	May	7.9	5.7	1347.2	2.1	3.5	5.8	7.9	7.0	39.2	2261.0	101.0	74.4	77.3
	June	8.1	6.0	1383.2	1.8	4.1	6.8	6.7	6.3	40.2	3637.0	151.2	75.3	78.7
	July	8.4	7.7	1553.8	0.5	4.7	7.0	6.5	4.4	37.7	4541.0	178.0	214.5	77.7
	August	8.6	15.5	3545.4	0.5	1.4	7.1	6.7	5.0	37.0	2164.2	221.2	239.7	95.2
	September	8.2	14.1	3216.7	1.1	0.7	7.2	6.6	2.7	36.8	1964.2	205.0	278.0	77.6
	Mean	8.2	6.5	1513.8	1.6	1.7	6.1	9.0	4.5	39.3	3162.4	109.6	111.5	56.3

Table 3: Chemical, physical and qualitative properties and measured heavy elements for the studied stations (middle part of Shatt Al-Arab).

St.	Months	PH	E.C ms/cm	Cl mg/l	NO3 mg/l	PO4 mg/l	NH4 mg/l	DO mg/l	BOD5 mg/l	Mn µg/ l	Fe µg/ l	Zn µg/ l	Pb µg/ l	Cd µg/ l
Al-Bhadria	October	7.8	3.9	1111.9	1.4	1.1	5.1	10.3	3.2	21.0	3886.0	31.0	56.0	10.8
	November	7.8	4.3	1007.8	1.3	1.1	7.0	10.2	3.3	63.0	4090.0	67.0	68.0	19.0
	December	8.2	3.9	1040.5	1.3	0.7	6.4	10.4	3.1	54.0	2206.0	27.0	73.0	13.0
	January	8.2	3.3	851.2	1.4	0.7	6.2	11.4	3.3	21.0	3688.0	53.0	74.0	18.0
	February	8.5	2.9	745.5	5.2	0.7	6.0	11.9	3.2	34.0	4621.0	61.0	91.0	71.0
	March	8.4	5.4	1275.7	5.1	0.7	6.1	11.4	4.2	43.0	4474.0	69.0	94.0	81.0
	April	8.3	5.5	1240.7	3.3	0.7	6.3	9.1	4.7	31.0	2731.0	77.0	55.0	85.0
	May	7.9	5.9	1312.0	2.9	3.5	6.5	7.0	6.9	30.0	2203.0	93.0	97.0	87.3
	June	8.1	6.0	1348.2	1.7	4.0	6.7	6.7	6.5	31.0	3274.0	75.0	99.0	87.5
	July	8.4	7.4	1691.2	0.8	4.8	8.1	7.0	3.5	39.8	1343.0	196.0	202.2	89.8
	August	8.6	16.1	3935.5	0.8	1.2	8.2	6.0	5.6	32.7	1855.2	339.7	290.5	73.9
	September	8.1	15.5	2862.2	1.1	0.6	8.2	6.5	2.4	51.2	1397.6	343.0	276.3	76.7
	Mean	8.2	6.7	1535.2	2.2	1.6	6.7	9.0	4.1	37.6	2980.7	119.3	123.0	59.4
Al-Majdlia	October	7.9	5.0	1481.8	1.4	1.2	4.1	10.9	3.8	35.0	3891.0	42.0	59.0	10.8
	November	7.8	5.6	1383.1	1.3	1.2	7.3	9.7	3.9	71.0	2940.0	71.0	68.0	17.0
	December	7.8	5.2	1284.4	1.4	0.7	6.0	10.5	3.5	34.0	2790.0	26.0	66.0	17.0
	January	7.7	4.3	1170.7	1.5	0.5	5.7	9.7	3.4	31.0	4627.0	59.0	77.0	20.0
	February	8.4	4.1	1092.3	4.4	0.5	5.6	10.9	3.3	38.0	5984.0	64.0	76.0	68.0
	March	8.2	6.0	1383.9	4.3	0.5	5.4	10.1	5.5	37.0	2929.0	71.0	72.0	71.0
	April	8.5	4.9	1116.8	3.2	0.7	5.5	9.8	5.7	31.2	2680.0	100.0	60.0	77.0
	May	8.0	6.1	1293.3	2.6	2.4	5.9	7.5	6.7	32.4	3607.0	132.0	52.0	78.6
	June	8.2	6.7	1343.1	2.0	3.9	5.9	6.9	5.9	30.8	3230.0	86.0	87.0	80.2
	July	8.4	9.1	1900.7	0.4	4.6	7.5	6.6	3.5	37.6	3020.0	207.0	246.5	74.5
	August	8.6	17.3	4427.9	0.4	1.0	7.6	4.8	3.8	53.6	1022.4	318.9	298.6	76.1

	September	8.3	13.5	3143.5	1.1	0.6	8.0	6.7	3.3	49.5	2364.1	313.7	271.2	54.3
	Mean	8.2	7.3	1751.8	2.0	1.5	6.2	8.7	4.4	40.1	3257.0	124.2	119.4	53.7
Abu Al-Khasib	October	7.8	5.6	1658.9	1.4	1.2	3.4	10.7	3.7	31.0	4231.0	47.0	50.0	17.5
	November	7.8	6.0	1510.5	1.3	1.2	8.0	9.9	3.8	61.0	2370.0	111.0	65.0	14.0
	December	8.2	5.7	1446.3	1.3	0.5	5.7	10.2	3.5	26.0	2140.0	65.0	65.0	11.0
	January	8.0	4.5	1205.7	1.5	0.4	5.5	10.8	3.3	33.0	5456.0	62.0	50.0	29.0
	February	8.4	4.4	1171.1	4.7	0.4	5.4	10.8	3.2	45.0	6495.0	63.0	55.0	81.0
	March	8.3	5.9	1328.8	4.6	0.4	5.6	10.6	5.8	47.0	6097.0	77.0	74.0	77.0
	April	8.5	6.1	1159.4	3.3	0.6	5.6	9.7	6.1	31.0	2600.0	96.0	69.0	83.0
	May	8.5	6.2	1292.6	2.7	2.5	5.9	7.1	6.1	32.1	2307.0	130.0	69.3	90.0
	June	8.2	6.1	1310.2	2.4	4.4	6.2	6.8	5.8	32.8	3056.0	92.0	82.4	89.0
	July	8.4	6.6	1367.8	0.6	5.1	8.4	7.4	4.7	39.7	1700.0	269.0	202.9	78.9
	August	8.5	20.3	4998.4	0.6	0.8	8.4	6.4	4.5	59.3	997.5	294.4	290.7	74.5
	September	8.2	17.4	4314.7	1.1	0.6	8.4	6.6	3.7	53.8	1547.9	291.8	288.6	79.9
	Mean	8.2	6.7	1535.2	2.2	1.5	6.4	8.9	4.5	41.0	3249.8	133.2	113.5	60.4
Saihan	October	7.9	9.4	2920.6	1.1	1.4	3.4	9.3	4.8	31.0	3541.0	35.0	78.0	18.7
	November	7.9	11.9	3458.1	3.1	1.5	8.7	8.9	4.9	58.0	4330.0	143.0	62.0	17.0
	December	8.0	11.7	3475.5	3.2	0.5	5.0	9.6	5.0	39.0	2832.0	24.0	63.0	19.0
	January	7.9	10.9	3282.9	3.3	0.4	6.0	10.1	3.5	33.0	5880.0	60.0	56.0	27.0
	February	8.3	6.0	1596.5	2.7	0.4	5.6	10.8	3.4	43.0	6363.0	59.0	69.0	81.0
	March	8.4	6.2	1309.5	2.7	0.4	5.7	8.5	4.3	32.0	3468.0	63.0	74.0	74.0
	April	8.0	7.4	1504.8	1.6	0.6	5.8	8.1	6.6	32.7	4796.0	115.0	60.0	73.0
	May	8.4	6.7	1524.0	1.6	2.4	6.0	7.1	6.8	36.2	3983.0	129.0	74.0	77.5
	June	8.0	9.4	1980.6	1.3	4.4	6.8	7.0	6.3	32.6	2443.0	159.0	102.7	79.0
	July	8.2	10.0	2142.4	0.4	5.1	6.8	6.7	3.7	35.3	5278.0	294.0	228.2	76.4
	August	8.4	21.3	6020.8	0.4	0.9	6.8	5.7	4.7	46.4	2105.6	328.4	249.2	76.6
	September	8.3	16.4	4229.5	1.3	0.6	6.9	6.8	2.5	46.2	1939.3	321.2	243.3	74.9
	Mean	8.1	10.6	2787.1	1.9	1.5	6.1	8.2	4.7	38.8	3913.2	144.2	113.3	57.8

Table 4: Chemical, physical and qualitative properties and measured heavy elements for the studied stations (southern part of Shatt al-Arab).

St.	Months	**PH**	**E.C ms/cm**	**Cl mg/l**	**NO3 mg/l**	**PO4 mg/l**	**NH4 mg/l**	**DO mg/l**	**BOD5 mg/l**	**Mn µg/ l**	**Fe µg/ l**	**Zn µg/ l**	**Pb µg/ l**	**Cd µg/ l**
Siba	October	8.0	12.5	4105.6	0.9	1.4	4.1	9.1	5.1	35.0	2362.0	38.0	59.0	13.2
	November	8.0	13.0	3753.1	1.4	1.4	9.0	9.3	5.2	76.0	5730.0	177.0	81.0	17.0
	December	8.1	11.5	3805.2	1.8	0.8	5.1	9.7	4.7	71.0	2426.0	133.0	63.0	29.0
	January	8.0	10.3	3404.7	2.6	0.6	4.6	10.1	4.5	35.0	5226.0	154.0	60.0	25.0
	February	8.1	6.3	1736.3	2.8	0.6	5.5	10.8	4.2	51.0	5091.0	154.0	68.0	74.0
	March	8.3	9.4	2375.0	2.8	0.6	4.5	8.7	4.5	39.0	3947.0	158.0	75.3	81.0
	April	8.1	8.0	2253.2	1.9	0.8	4.6	8.7	5.4	31.0	1985.0	167.0	76.0	82.1
	May	7.9	8.5	2268.7	1.8	2.3	4.9	7.7	6.5	35.1	1576.0	162.0	76.2	55.3
	June	8.0	12.5	3045.2	1.7	4.5	7.1	6.9	5.9	38.2	2977.0	165.0	117.1	89.0
	July	8.1	12.9	3118.7	0.8	5.1	7.3	6.7	3.2	51.5	2205.0	323.0	259.3	85.0
	August	8.6	25.1	6124.1	0.8	1.5	7.4	5.2	4.1	48.8	2530.2	330.8	261.6	96.7
	September	8.2	17.8	3654.7	1.3	0.6	7.2	6.8	2.9	47.9	2199.3	326.2	250.6	91.3
	Mean	8.1	12.3	3303.7	1.7	1.7	5.9	8.3	4.7	46.6	3187.9	190.7	120.6	61.5
Al-Dhuaib	October	8.0	13.3	4459.5	1.1	1.4	3.9	9.3	5.3	49.0	5364.0	40.4	58.0	14.5
	November	8.0	13.5	4250.1	1.8	1.4	9.2	9.1	5.4	80.0	6660.0	201.2	71.0	26.0
	December	7.9	12.1	3979.6	1.9	1.0	6.2	9.7	4.9	47.0	2350.0	22.0	74.0	13.0
	January	7.8	10.5	3529.9	2.8	0.8	5.0	10.1	4.6	45.0	5189.0	65.0	59.0	31.0
	February	8.1	6.3	1742.3	2.9	0.7	4.7	10.6	4.5	68.0	7315.0	66.0	66.2	81.0
	March	8.4	7.9	2250.8	2.8	0.8	4.7	8.8	4.5	35.0	3627.0	60.0	72.2	84.0
	April	8.2	8.6	2288.3	1.9	0.9	4.8	8.8	4.6	32.5	3998.0	157.0	75.0	85.0

	May	8.0	9.0	2339.5	1.3	2.5	5.0	7.7	6.0	33.1	3158.0	161.0	107.0	87.0
	June	8.0	11.1	3008.4	1.6	4.5	7.3	7.0	6.3	33.6	3265.0	162.0	151.0	91.2
	July	8.1	14.7	3382.4	0.5	5.1	7.5	6.4	4.7	45.5	1387.0	281.0	243.7	92.5
	August	8.6	27.3	6407.4	0.5	0.8	7.6	5.9	4.5	47.0	1747.1	364.2	277.9	95.8
	September	8.2	15.9	2914.2	1.2	0.6	7.6	6.7	3.3	46.0	1530.9	337.2	276.0	89.4
	Mean	8.1	12.5	3379.4	1.7	1.7	6.1	8.3	4.9	46.8	3799.2	159.8	127.6	65.9
	October	8.0	17.9	5274.9	0.8	1.5	4.8	9.4	4.1	61.0	6948.0	71.1	59.0	26.4
	November	7.9	17.8	5319.0	5.5	1.6	10.2	9.3	4.2	65.0	6990.0	317.0	68.0	27.0
	December	8.0	15.4	4621.7	5.6	0.8	9.3	9.5	3.9	63.0	4942.0	46.0	65.0	20.0
	January	7.9	12.8	3937.7	5.8	0.7	9.0	10.2	3.8	65.0	2933.0	77.0	90.0	38.0
	February	8.1	11.9	3735.7	5.9	0.6	8.9	11.1	3.3	133.0	8776.0	84.0	93.9	40.6
Al-Faw	March	8.2	17.2	4974.1	5.2	0.6	9.0	9.0	3.9	152.0	6405.0	90.0	91.8	43.1
	April	8.4	14.9	4984.9	4.0	0.7	9.0	8.8	5.2	133.9	2834.0	160.0	93.0	45.3
	May	8.2	16.4	5027.2	2.1	2.5	9.4	7.7	6.2	147.3	6837.0	193.0	95.3	49.1
	June	8.2	28.2	8908.7	1.7	5.1	10.1	7.0	6.6	140.0	2757.0	227.0	190.7	95.1
	July	8.2	26.6	8133.4	0.5	5.6	10.2	6.6	4.1	163.8	3201.0	348.0	340.5	95.8
	August	8.4	27.9	6543.7	0.5	2.2	10.3	4.7	4.1	158.3	2605.4	438.6	368.3	106.3
	September	8.3	28.8	7134.2	1.5	1.7	10.2	7.0	2.0	96.7	1197.3	296.6	307.9	98.2
	Mean	8.2	19.6	5716.3	3.2	1.9	9.2	8.3	4.3	114.9	4702.1	195.7	155.3	57.1
	October	8.1	18.3	6112.0	0.8	1.8	3.6	9.4	4.7	55.0	3743.0	87.0	65.0	26.4
	November	8.1	18.0	5388.2	5.9	1.6	11.6	9.3	4.8	63.0	3840.0	409.0	78.0	28.0
	December	8.1	15.9	4870.6	6.0	1.4	9.2	9.6	4.3	48.0	2975.0	66.0	77.0	20.0
	January	8.0	13.3	3884.5	6.0	1.0	9.0	10.2	3.6	45.0	2933.0	89.0	90.0	38.0
	February	8.0	12.3	3706.2	6.0	0.9	8.7	11.0	3.2	126.0	4618.0	91.0	91.2	38.2
Al-Naqaa	March	8.2	16.6	4922.2	5.4	1.0	8.8	8.2	3.3	59.0	6416.0	93.0	91.9	36.0
	April	8.3	15.8	4879.1	3.6	1.0	8.9	8.2	3.7	33.1	3837.0	123.0	63.0	34.0
	May	8.1	16.4	4902.3	2.5	2.8	9.3	7.5	6.2	34.3	2665.0	155.0	78.4	21.2
	June	8.2	27.9	8527.0	2.0	5.1	12.7	7.0	6.6	135.6	4818.0	207.0	184.4	93.1
	July	8.2	26.5	8021.2	0.4	5.6	10.2	6.7	3.4	141.4	2878.0	305.0	380.8	92.5
	August	8.1	28.3	6887.7	0.4	7.0	10.1	4.7	4.3	158.5	2772.2	451.8	388.9	101.9
	September	8.3	29.7	7628.2	1.7	2.6	10.0	7.0	2.2	90.5	1331.0	332.9	359.2	98.7
	Mean	8.1	19.9	5810.8	3.4	2.6	9.3	8.2	4.2	82.5	3568.9	200.8	162.3	52.3

Results and Discussions

Properties adopted in the water quality index (Canadian pollution model):

The water characteristics approved in this guide are pH (PH), (E.C), nitrates (NO3), chloride (Cl), in addition to the heavy elements, which are manganese (Mn), iron (Fe), zinc (Zn), lead (Pb), and cadmium (Cd), which was compared with the standard standards approved according to the Iraqi Rivers Protection System from Pollution for the year 1967, as shown:

Electrical conductivity E.C.:

Table (1, 2, 3 and 4) shows the variation in electrical conductivity values locally according to the stations under study and according to the month in which the measurement was made. The northern stations of the Shatt al-Arab (Qurna, Paper Mill, Hartha, Najibiyah, and Ports) recorded low values compared to the northern stations, its lowest value was in the first station (Qorna), which was 1.2 ms.cm-1. This was followed by the second station (the paper mill), recording the value (1.3 ms.cm-1). The reason for this is the distance of these stations from the salty influence coming from the Gulf, in addition to the lack of pollutants dumped in the river at the beginning of the city, while the stations located in the southern part of the Shatt al-Arab (Seyhan, Siba, Al-Duweib, Al-Faw and Al-Naqaa) recorded high values of electrical conductivity, it reached its highest value in Al-Naqaa (the sixteenth station), which is (29.7 ms.cm-1), followed by the fifteenth station, (28.8 ms.cm-1). The reason for this is due to the increased influence of the salty waters of the Gulf on these stations and what they throw during the tides, in addition to increasing the effect of sewage waste dumped in the river and the dissolved salts it contains at high concentrations, this was confirmed by Al-Mahmoud (2015) in his study by analyzing the discharge and salinity data in the Shatt Al-Arab from the height, salt concentrations in the Shatt Al-Arab, especially in the years 2009-2018 - especially in the southern part of the river between Seyhan and Al-Faw, as for monthly changes in electrical conductivity, it was clear during the study period, the first station (Al-Qurna) recorded the lowest values in electrical conductivity during the month of February (1.2 ms.cm-1), at an annual rate of (3.0 ms.cm-1), then the second station (paper mill) recorded the value (1.3 ms.cm-1) in February also at an annual rate of (3.1 ms.cm-1). The reasons for this are due to the dilution of the salinity of the water due to the increase in water discharge and the low evaporation rates as a result of the low temperatures, while the stations under study recorded high values in the conductivity values during the summer months, which are September, October and the second, especially in the Faw-Naqaa stations. The macula recorded the highest value (29.7 ms.cm-1) in September, with an average value of (19.9 ms.cm-1), this was followed by the station (Al-Faw), recording a value of (28.8 ms.cm-1) in September also, at an annual rate of (19.6 ms.cm-1), due to the lack of drainage of the Shatt al-Arab as a result of the low water levels of the Tigris and Euphrates rivers and the closure of some tributaries such as the Karun River as a result of some water policies, Moyel and Hassain (2015) had a clear impact on that, statistical analysis showed that there were significant differences ($P>0.05$) between the measured months, as well as significant differences between the measured stations.

pH:

Table (1, 2, 3 and 4) shows the changes in the pH values of the stations under study, which were somewhat close and in the basal direction throughout the study period, an important and distinctive feature of Iraqi water, and previous studies confirmed it in the Shatt Al-Arab. The reason for this is due to the high regulatory capacity of water due to the high presence of carbonates and bicarbonates, and to the high values of pH from the Tigris River section in the city of Basra (Al-Khuzaie, 2014; Hamad, 2015). The lowest recorded value was (7.8) in the first station (Al-Qurna) and the sixth station (Al-Ashar) in October and November, and in the second station in January, as for the highest recorded value, it was (8.6) in more than one station and in the month of August. These stations are (Al-Najibiya, Al-Hartha, Al-Baradia, the Presidential Palaces, Al-Bahadria, Al-Muhaila, and the fourteenth third station (Siba and Al-Duaib). The reason for this is due to the decrease in the discharge of the river and the rise in the concentrations of dissolved salts in the water due to the increase in evaporation, the progress of salt currents towards the north of the river, and this is consistent with what Al-Sabah (2007) concluded that the rise in the alkaline water in the Shatt Al-Arab, was due to the entry of salty water currents during the tidal phenomenon, which contain concentrations of bicarbonate leading to an increase in the pH value, the results of the statistical analysis showed significant differences ($P< 0.05$) between the months and stations under study.

Chloride (Cl):

The results show that the lowest recorded value was 317.2 mg.L-1 in the second station (Paper Mill) during February, then the first station (Al-Qurna). The reason for the low chloride ion values in these stations may be due to their distance from the salinity effects during the tidal phenomenon, as well as the effect of rainfall and the increase in river discharge accordingly, which works to reduce the salts during the cold months, while the highest recorded value was 8908.7 mg.L-1 in the fifteenth station (Al-Faw) in June, then the value recorded during the month of July and for the same station. The reason for this is due to the low discharge of water from the Tigris and Euphrates and the high rise in temperatures, especially during the summer season, which increases the concentrations of dissolved salts in the water towards the south from the Shatt Al-Arab. The chloride ion is present in high concentrations in wastewater compared to raw water, because sodium chloride is a major substance in the diet, its use in purification operations, in addition to the connection of the Shatt al-Arab to the secondary channels laden with sewage water and agricultural and industrial waste, previous studies have shown high concentrations of chloride, which exceed Iraqi and international standards, as Al-Ashar recorded a concentration of up to (3360 mg.L-1), while the lowest concentration was in Al-Uzair (330 mg.L-1) during the winter of 2018, which exceeded the standards of the World Health Organization (250 mg.L-1), (Zahraa et al., 2020). The results of the statistical analysis are significant differences between the stations chosen in the study, as well as significant differences between the months ($P>0.05$).

Nitrates (NO3):

The lowest value of nitrates (0.3 mg.L-1) was recorded in the second station (Paper Mill) during July and August. The reason for the decrease in nitrate values during the summer months and for all stations may be due to the high consumption of nitrates by plants and phytoplankton due to the decrease in dissolved oxygen, while the highest value (6.0 mg.L-1) was recorded in the last station (Al-Naqaa) in the months of December, January and February. The reason for the rise in nitrate values during the cold months of the study is attributed to despite the decrease in salt concentrations, because of the rains that help dissolve organic compounds and the addition of nitrogen fertilizers to agricultural lands, which finds its way through canals and branches towards the river, also, the rise in dissolved oxygen values during the cold months accelerates the conversion of ammonia into nitrates due to the increase in microbial activity. These results are consistent with what was reached by Hamdan et al. (2018) in his study of the chemical and physical properties of 37 sites along the course of the Shatt Al-Arab, the highest value for nitrates was recorded in site 29, which is (10.24 mg L-1), while the lowest value recorded in site 7 was (1.56 mg L-1), these values are acceptable according to the surface water quality standards and the Iraqi specifications for water quality (1998). The results of the statistical analysis showed significant differences ($P>0.05$) between the measured months, as well as significant differences ($P>0.05$) between the stations under study.

Phosphate (PO4):

Tables (1, 2, 3 and 4) showed the phosphate values in the stations selected in the study, as the lowest value (0.4mg L-1) was recorded in the stations (paper mill, Abu Al-Khasib and Seyhan) during the months of January, February and March, while the highest value (7.0 mg L-1) was recorded in the last station (Al-Naqaa) during the month of August, followed by Al-Faw and Al-Naqaa station also at a rate of (5.6 mg L-1) in July, as an annual average for the studied stations. The second station (Paper Mill) recorded the lowest rate, which is (0.9 mg L-1), then the first station (Al-Qurna) and the fourth (Al-Najibia) (1.2 mg L-1), while the last station (Al-Naqaa) recorded the highest annual average in phosphate values, which was (2.6mg L-1), then the fifteenth station (Al-Faw) registered (1.9 mg L-1). The reason for this is due to the subtraction of waste, agricultural and industrial waste and sewage, which increases as we advance from Al-Qurna towards Al-Faw, and its increase during the summer months compared to the cold months (Gatea, 2018), by the study of Zahraa et al. (2020), indicated that the waters of the Shatt Al-Arab were deteriorating compared to previous years, because of the high salt concentrations and the effect of the incursion of the salt tongue from the Gulf into the river water, which made it unfit for human, agricultural and animal consumption.

Ammonium (NH4):

Table (1, 2, 3 and 4) showed the temporal and spatial changes in ammonium values in the stations under study. The first station (Al-Qurna) recorded the lowest annual rate compared to the other stations, which was (3.6 mg L-1), while the last station (Al-Naqaa) which was (9.3 mg L-1), meaning that the increase in the concentration of ions increases as we move towards the south of the river, temporal variations, the lowest recorded value was (2.7 mg L-1) in the first station (Al-Qurna) and during the month of February, while the highest value of ammonium was (12.7 mg L-1) in the last station (Al-Naqaa) during June, followed by (11.6 mg L-1) for the same station during November, agrees with Al-Mahmoud (2020) found that salt concentrations increase towards the south of the river, especially in recent times, there were many reasons for this, including the increasing population pressure on the water, led to an increase in the salt penetration of the Gulf waters towards the upper reaches of the river, in addition to global and local climate change due to the increase in the area of barren land, in addition to the waste of agricultural and industrial waste.

Dissolved oxygen (DO):

Tables (1, 2, 3 and 4) showed dissolved oxygen concentrations in the stations chosen in the study, which varied according to the locations of the stations and the time they were measured. The lowest concentration (2.2 mg L-1) was recorded in the second station (the paper mill) during the month of September, while the station (Al-Bahadriyah) recorded the highest concentration (11.9 mg L-1) in February, and as an annual average, the second station (Paper Mill) recorded the lowest rate (3.6 mg L-1), then it was followed by the first station (Al-Qurna) recording the average (4.0 mg L-1), these values were less than the recommended limits according to the Rivers Conservation System No. 25 of 1967 adopted in this study, which determined the concentration of dissolved oxygen (>5 mg L-1), meaning that this water is of poor quality and is not suitable for use, while the stations (Al-Ashar, Al-Baradia, Presidential Palaces and Al-Bahadria) participated in the highest rate, which was (9.0 mg L-1). The reason for this is due to the effect of water temperature and its inverse relationship with dissolved oxygen as we noticed an increase in the value of any oxygen during the cold months and its decrease in the summer months, because of the high consumption of dissolved oxygen during the hot months by aquatic organisms in the oxidation and decomposition of organic and inorganic substances present in the water, and these results are consistent with the findings of the researcher (Gatea, 2018) in his study of the water quality of the Shatt al-Arab for the period January 2013-April 2013, for six stations (Al-Qurna, Basra, Al-Maqal, Abu Al-Khasib, Siba and Al-Faw), as the dissolved oxygen concentrations recorded were within the range of 9.66-4.05 mg L-1, with an average value of (5.72 mg L-1). It also agrees with the findings of the researcher Hassan et al. (2018). The dissolved oxygen values of the studied stations on the Shatt Al-Arab were confined between the highest recorded value which was (9.84 mg L-1) and the lowest value was (2.26 mg L-1) with an average of (7.27 mg L-1) during 2014.

Biological Oxygen Demand (BOD5):

The results showed that the lowest value recorded for the biological oxygen demand was (2.1 mg L-1) in Al-Baradia during the month of September, then it was followed by the sixteenth station (Al-Naqaa) recorded (2.2 mg L-1) and during the month of September as well, (Tables 1, 2, 3 and 4), it was known that the waters of the Shatt Al-Arab have a high level of pollution due to the various pollutants present in it, whether it is the remains of agricultural fertilizers, factory waste, or sewage water, all of these wastes contain large quantities of organic and chemical compounds, which microorganisms decompose to take advantage of them as energy sources, so the dissolved oxygen decreases, in addition to the decrease in water levels during the summer months, all of which raise BOD5 values (Al-Khuzaie, 2014). However, in our study, we noticed a decrease in BOD5 values during the summer months. The reason for this is attributed to the acute shortage of dissolved oxygen during the summer months compared to the winter months, therefore, the organisms do not find enough of it during the incubation period, which leads to a decrease in the value of the vital requirement for oxygen. In this case, it needs aeration operations for the samples taken before incubation, as for the highest recorded value, it was (7.1 mg L-1) in (Al-Najibia), then it was followed by the station (Presidential Palaces) with a value of (7.0 mg L-1) during the month of May. The reason for this may be due to the fact that these areas are agricultural or close to sewage disposal stations, which leads to an increase in the value of the vital requirement for oxygen, as an annual average, the second station recorded the lowest rate (3.6 mg.L-1), then the first station (4.0 mg.L-1), while the station (Al-Duib) recorded the highest rate, which is (4.9 mg.L-1), then Al-Seba and Sihan at the same rate (4.7 mg.L-1), according to the annual rates of the studied stations, the BOD5 values are within the approved limits in the system of protecting rivers from pollution, these values are consistent with the findings of the researcher Amal M. Eassa et al;2015), where the values of BOD5 were (5.2-2.9) and (3.5-2.2) (4.0-3.4) mg L-1, for the Al-Qurna, Al-Deir and Abu Al-Khasib.

Heavy metals:

Tables (1, 2, 3 and 4) show the concentrations of heavy elements in the Shatt Al-Arab water, and these elements are (manganese-iron-zinc-lead-cadmium), the lowest value recorded for manganese was (17.0 µg.L-1) in the second station (Paper Mill) during October, while the highest value was recorded in the fifteenth station (Al-Faw), which is (163.8 µg.L-1) during July, as an annual rate, the second station (Paper Mill) recorded the lowest rate, which is (31.4 µg.L-1), while the fifteenth station (Al-Faw) recorded the highest rate, which is (114.9 µg.L-1), all stations chosen in the study were within the allowable range (100 µg.l-1) in terms of manganese concentrations, except for the fifteenth station (Al-Faw), which recorded higher than that, as mentioned above.

As for iron, the lowest recorded value was (997.5 µg.L-1) in (Abu Al-Khasib) in August, while the highest value was recorded in the station (6990.0 µg.L-1) and also in August, while the lowest annual rate was (2980.7 µg.L-1) in the station (Al-Bahadria) and the highest rate was in the (Al-Faw) station, which was (4702.1 µg.L-1), and this means that the iron concentrations were high in all the stations studied according to the parameters of the river maintenance system, which determined the concentrations Iron (300 µg.L-1).

As for the zinc, the station (Ports) recorded the lowest value, which is (20.0 µg.L-1) in the month of October, while the highest value was (451.8 µg.L-1) and it was recorded by the station (Al-Naqaa), and as an annual average, the station (Al-Najibia) recorded The lowest rate was (95.1 µg.L-1), and the highest rate recorded in the last station (Al-Naqaa) was (200.8 µg.L-1). This means that the concentrations of zinc in Shatt Al-Arab water did not exceed the standard limits set for pollution of river water, which were determined in concentration (500 µg.L-1).

As for lead, the lowest recorded value was (35.0 µg.L-1) in the station (Al-Ashar) during the month of January, and the highest value recorded in the station (Al-Naqaa), which was (388.9 µg.L-1) during the month of August. As an annual average, it was recorded The station (Paper Mill), the lowest rate, which is (93.0 µg.L-1), and the highest rate ((162.3 µg.L-1) was recorded in the station (Al-Naqaa), meaning that the lead concentrations exceeded the approved limits in the system of protecting rivers from pollution, which Determine the concentration (50 µg.L-1).

As for the last element, cadmium, its lowest value (0.3 µg.L-1) was recorded in the station (Al-Hartha), and the highest value (106.3 µg.L-1) was recorded in the station (Al-Faw), while the lowest annual rate was recorded in the third station. (Al-Hartha), which was (15.3 µg.L-1), and the highest annual rate was (65.9 µg.L-1) in the station (Al-Duwaib), meaning that cadmium concentrations also exceeded the limits set for pollution of rivers, as the concentration was determined (5 µg.L-1), and from all of the above, it can be said that the waters of the Shatt al-Arab are polluted with heavy elements (iron, lead and cadmium), and that the heavy metal pollution resulted from several factors, including human activities, especially agricultural operations (fertilizers, pesticides, herbicides), decomposition of garbage, sewage and polluted air The main sources of pollution are represented by the contribution of natural sources. It was found that the levels of heavy metals in rivers and soil sediments close to industrial areas have high concentrations compared to other sites in Basra (Akesh, 2016). Thus, the heavy metals measured in this study can be arranged according to their concentrations in The stations studied above are as follows:

Iron > zinc > lead > manganese > cadmium

Water quality index (Canadian model):

The results of table (6) showed the index values for the selected stations for two important seasons in the region, which are the summer and winter seasons, and also as an annual average for twelve months from October (2021) to September 2022), as follows:

Summer season:

This season represents the months (June, July, August and September), as the results of the table (1, 2, 3, 4) showed a significant increase in the concentrations of the measured variables affecting the water quality, which are the electrical conductivity (E.C), pH (PH), and ions (Cl-, NO-, PO4-2, and NH4+) and heavy elements (Mn, Fe, Zn, and Cd) at all selected stations along the Shatt al-Arab stream, when compared with the approved standard standards according to the Iraqi Rivers Protection System from Pollution for the year 1967, the results of Table (6) showed a decrease in the index values, but to different degrees according to the location of the station, but all of them were between the range (30-21) and within the category (poor), meaning that it is water It is always polluted, far from ideal, and unsuitable for use. The second station (Paper Mill) recorded the lowest value in the index during this quarter (21). The reason for this is due to the presence of the paper mill and the resulting industrial waste in this area in particular, in addition to the Al-Hartha power station and Al-Najibiya power station, all of which affect the quality of the river's water, including the water it consumes and the waste it excretes (Mohammed and Al-Chalabi, 2022). As for the highest value in the index, it was (30), which was recorded in the first station (Al-Qurna), and this is consistent with what Al-Mahmoud (2020) concluded, that there is a correlation between the decrease in river discharge and the increase in the salinity rate, and that this change in salinity does not take a single pattern It varies according to the location of the stations. The stations located in the southern part of the river had high salinity rates compared to the stations located in the northern part, and also according to the seasons, so the summer and autumn seasons had a similar effect to drought and different from the winter and spring seasons, i In addition, the stations located from Al-Maqal station to the Abu Flus port station are low areas, where the salty marine water comes from the Gulf and stays for longer periods, which made it a storage basin for salty water, t Therefore, it needs many expenditures and long periods of the Tigris River to push this salty water towards the sea (Zahraa et al., 2020).

Winter season:

This season was represented by the months (January-February-March-April), as the results of Table (1, 2, 3 and 4) showed an increase in the values of the water quality index (WQI) compared to the summer season index, the values during this chapter were confined between the range (21-38) and within the (poor) category. The first station (Al-Qurna and Al-Hartha) recorded the highest value in the index, which is (38), while the fifteenth station (FAO) recorded the lowest value, which is ((21), then it was followed by the station (Al-Muhahila and Al-Naqaa), recording the value (27-28), respectively. The reason for the increase in the index values is due to the increase in river discharges due to rain and the decrease in evaporation rates, which affected the values of electrical conductivity, negative and positive ions, and other variables measured according to the Iraqi Rivers Protection System from Pollution for the year (1967). This is consistent with what was reached by Moyel and Hussain (2015), as the results of their study on the Shatt al-Arab showed that the decline in the discharge of the Shatt al-Arab and the Shatt al-Basra affected the water quality and its validity. Dams and barrages, but in the southern part of the Shatt Al-Arab, the greatest influence of the Arabian Gulf, as well as the influence of other factors such as agricultural activities, sewage water and waste from plants, the coincided decrease in salinity values during the winter due to increased discharge, lower temperature, increased humidity and increased precipitation.

Annual rate:

Table (5) shows the annual rate in the calculation of the Canadian Index (CCME) for water pollution, which included all months of the year, starting from October 2021 to September 2022, all stations were of value to the guide confined between (32-20) and fall within the category (Poor) according to the system of maintaining Iraqi rivers from pollution for the year (1967). The stations located in the northern part of the Shatt al-Arab recorded the highest value (32), which was Al-Qurna and the paper mill, while the stations located in the southern part of the river recorded the lowest value, which is (20), which was Al-Faw, due to the lack of water discharge across the Tigris and Euphrates rivers towards the south from the Shatt al-Arab and the intrusion of salty water from the Arabian Gulf, as well as waste disposals that increase as we go deeper into the river, deterioration occurs and water becomes unacceptable (Abdul-Razak et al., 2016). In a study also to estimate the water quality of the Shatt al-Arab using the Water Quality Index (WQI) in the areas near the power stations in al-Hartha and al-Najibiyah during the dry season (August 2016) to the wet season (January 2017), it was concluded that the river water is very poor during the summer, while its quality ranges from very poor to unfit during the winter season, and there is a clear effect of power plants on this deterioration (Al Aboodi et al., 2018).

Table (5): Water Quality Index (PWQI) values and their taxonomic categories for the different study stations and periods.

Stations	Study periods	(PWQI) values	Taxonomic categories
Al-Qurna	Winter	**38**	**POOR**
	Summer	**30**	**POOR**
	Annual rate	**32**	**POOR**
Paper mill	Winter	**35**	**POOR**
	Summer	**21**	**POOR**
	Annual rate	**32**	**POOR**
Al-Hartha	Winter	**38**	**POOR**
	Summer	**27**	**POOR**
	Annual rate	**31**	**POOR**
Al-Najibia	Winter	**29**	**POOR**
	Summer	**22**	**POOR**
	Annual rate	**20**	**POOR**
Ports	Winter	**32**	**POOR**
	Summer	**26**	**POOR**
	Annual rate	**29**	**POOR**
Al-Ashar	Winter	**32**	**POOR**
	Summer	**26**	**POOR**
	Annual rate	**28**	**POOR**
Al-Bradhia	Winter	**29**	**POOR**
	Summer	**25**	**POOR**
	Annual rate	**28**	**POOR**
Presidential palaces	Winter	**31**	**POOR**
	Summer	**24**	**POOR**
	Annual rate	**28**	**POOR**
Al-Bhadria	Winter	**34**	**POOR**
	Summer	**25**	**POOR**
	Annual rate	**27**	**POOR**
Al-Muhaila	Winter	**27**	**POOR**
	Summer	**22**	**POOR**
	Annual rate	**27**	**POOR**
Abu Al-Khasib	Winter	**31**	**POOR**
	Summer	**24**	**POOR**
	Annual rate	**27**	**POOR**
Sayhan	Winter	**31**	**POOR**
	Summer	**25**	**POOR**
	Annual rate	**27**	**POOR**
Al-Siba	Winter	**30**	**POOR**
	Summer	**24**	**POOR**
	Annual rate	**26**	**POOR**
Al-Duib	Winter	**32**	**POOR**
	Summer	**24**	**POOR**
	Annual rate	**25**	**POOR**
Al-Faw	Winter	**21**	**POOR**
	Summer	**22**	**POOR**
	Annual rate	**20**	**POOR**
Al-Naqaa	Winter	**28**	**POOR**
	Summer	**22**	**POOR**

	Annual rate	**24**	**POOR**

Conclusions

The Canadian Water Quality Index is an important model for determining water quality in the region and can be adopted for that purpose, because it represents a set of chemical, physical and qualitative characteristics of water. 2- The quality of the water in this guide was classified within the class (poor), which is the lowest class in the guide and indicates that the river water is weak, deteriorating and polluted according to the system of maintaining Iraqi rivers from pollution for the year 1967. The negative effects, whether environmental, industrial, demographic, agricultural factors and heavy elements, gradually increase as we go south of the river, becoming more severe in the last station, which is (Al-Naqaa) and during the summer compared to the winter. The salt concentrations rose to high levels when compared to previous years. Iron, lead and cadmium can be counted among the heavy elements polluting the waters of the Shatt al-Arab, due to their presence in quantities that exceed the standard limits set in the system for protecting Iraqi rivers from pollution.

Recommendations

The guide can be adopted in water management, and to provide the responsible authorities and administrators who are not specialized in water with sufficient information to determine the quality of water and its quality, with continuous monitoring by the concerned authorities and to stand up to the problem and remedy it. The classification of water in the studied stations within the category (poor), requires all responsible authorities to take a serious stance to solve this problem and put in place laws and regulations that prevent waste of all kinds from being thrown into water sources without treatment, as its effects will be disastrous for everyone. There must be stations to treat polluted water before dumping it into the river, distributed along the course of the river, as well as requiring factories and laboratories to have treatment units and closing factories that do not have wastewater treatment units, or the presence of treatment units, but they are not effective. Due to the dangerous pollutants received by these laboratories. The need for the government in Iraq to conclude water agreements with upstream countries such as Turkey and Iran that require increasing water releases and restoring some tributaries such as the Karun and Karkheh to increase water supply and reduce salt concentrations in the river. Paying attention to scientific research regarding water, its management and financing, and predicting its future conditions. Establishing more rigorous water quality indicators in Iraqi rivers, in line with international standards. Working on establishing modern Iraqi standards for Iraqi water that are compatible with the conditions of the region.

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