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Original Article

Water quality assessment of Al-Sabil River, Iraq using of CCME index

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Abstract: The study aimed to determine the water quality of the Al-Sabil River using the Canadian Water Quality Index (CCME WQI). The study was performed by measuring some physical and chemical properties in four selected sites that extend in three provinces including Najaf, Al-Diwaniyah, and Al-Muthanna for a distance of 114 km for six months from August 2022 to January 2023. The results revealed that the average physical and chemical properties, including water temperature, pH, and EC were 19.33-25.33℃, 7.25-7.54, and 1138-2510 µs/cm, respectively. The total suspended solids and turbidity recorded 1261-1676, 30.1-47.78, respectively. The DO and BOD have been recorded at 6.417-7.1, and 3.467-6.133 mg/L respectively. The total hardness, Ca, and Mg were 630-853.3 mg/L, 146.3-192.7 mg/L, and 87.39-236.19 mg/L, respectively. The phosphate, nitrite, and nitrate (mg/L) were 0.591-0.887, 0.486-1.539, and 1.772-6.921, respectively. The results of the study using the Canadian model water quality index (CCME WQI) showed that the lowest rate was 44.35 showing a poor condition in the first site and the highest rate was 51.41 as a marginal condition in the 3rd site.

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Introduction

The aquatic ecosystems are the most diverse since water is the most important medium for living organisms worldwide. The river ecosystems are more sensitive to pollution due to human activities, including agriculture, urban, and industrial sewage waters that affect aquatic organisms (Hamid et al., 2020). Water quality is also affected by natural processes such as geology, hydrology, and climate in addition to human activities (Alam and Laishram, 2017). Water quality assessment is the process of determining its physical, chemical, and biological characteristics. The water quality indicators, including the Canadian Water Quality Index (CCME WQI) aim to provide values to understand the water quality in a simple way and an easier expression to interpret the data (Bhart and Katyal, 2011).

Many developing countries are affected by the deterioration of their water quality as a result of different pollutants, especially those associated with human activities that are dumped into rivers causing a clear imbalance in water quality. These polluting materials, including industrial wastewater, agricultural water, and urban sewages enter directly into rivers (AL-Mayah, 2018). Water also has different uses such as drinking, irrigation, agriculture, as well as industrial activities, and hydroelectric power generation. Hence, water quality is affected by the increase in population and various human activities (Kareem et al., 2021). The Canadian Model Water Quality Index (CCME WQI) was used in many studies (Barsukova et al., 2021). Therefore, this study aimed to determine the water quality of the Sabil River using the Canadian Water Quality Index (CCME WQI) by selecting four sites in this river.

Materials and Methods

The study was done in the Al-Sabil River for six months from August 2022 to January 2023: the first site was near Al-Ya'o Dam in Al-Qadisiyah district in Al-Najaf province, the second site in Al-Shinafiyah district in Al-Diwaniyah province, the third as at Al-Dashish village, north of Al-Muthanna province, and the fourth site was in Al-Majd in Muthanna province

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Table 1. Composition (%) and added bacteria for different experimental diets.

Factors	ST1	ST2	ST3	ST4
Water Temperature	19.33	22.83	25.33	25
PH	7.39	7.53	7.55	7.29
Electric Conductivity	1543	1767	1684	2050
Total Dissolved Solids	1267	1261	1676	1524
Turbidity (TUR)	33.35	30.1	47.02	47.78
Dissolved Oxygen	6.68	7.1	6.98	6.42
Biological Oxygen Demand	6.13	4.18	3.47	5.18
Total Hardness	750.8	630	853.3	760.7
Calcium	192.7	161.3	168.4	146.3
Magnesium	135.6	113.9	166.4	149.3
Phosphate	0.89	0.62	0.73	0.59
Nitrite	0.67	1.18	0.48	1.54
Nitrate	4.55	3.124	4.379	5.224
CCME-WQI	44.35	50.36	51.41	47.49

(Fig. 1).

The water temperature in the field was measured using a thermometer (°C). The pH value and electrical conductivity were measured in the field using a portable pH meter model. The dissolved oxygen and BOD5 were determined using the Winkler method. Total dissolved solids (TDS) by (Maiti, 2004) turbidity (TUR), total hardness (TH), calcium (Ca), magnesium (Mg), phosphate (PO4), nitrite (NO2), and nitrate (NO-3) were determined following standard methods (APHA, 2017). Magnesium (Mg) was measured based on Lind (1979). The nitrites and nitrates were measured by a UV spectrophotometer with a wavelength of 220 nm. Phosphate was determined by a spectrophotometer at a wavelength of 860 nm. The Canadian Model Water Quality Index (CCME-WQI) was used to assess the water quality of the Sabil River to live organisms according to CCME (2001).

Results and Discussion

The results showed the lowest average water temperature as 19.33°C (site 1), and the highest as 25.33°C (site 3) (Table 1). The lowest water temperature (10°C) was recorded in January 2023 (Site 1) and the highest value (37°C) in August 2022 (site 4) (Fig. 2). Temperature differences may be due to different timing of sampling, seasonal variation, and the influence of atmospheric temperature. This is because of the direct relationship between water and air temperature in the lotic systems (Wetzel, 2001).

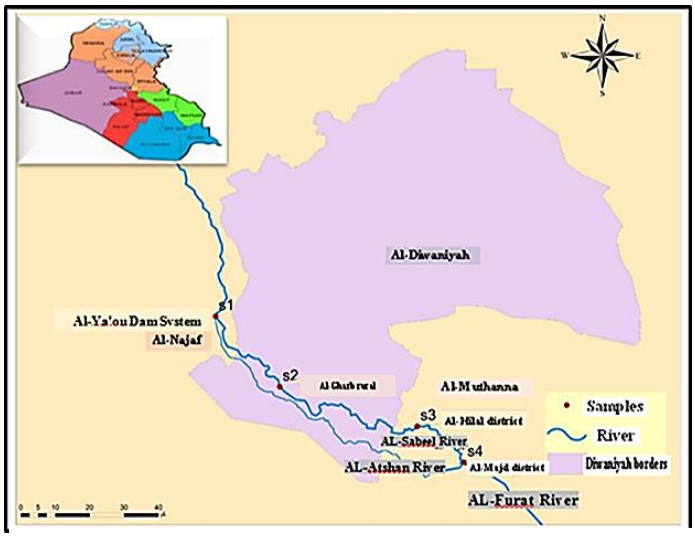
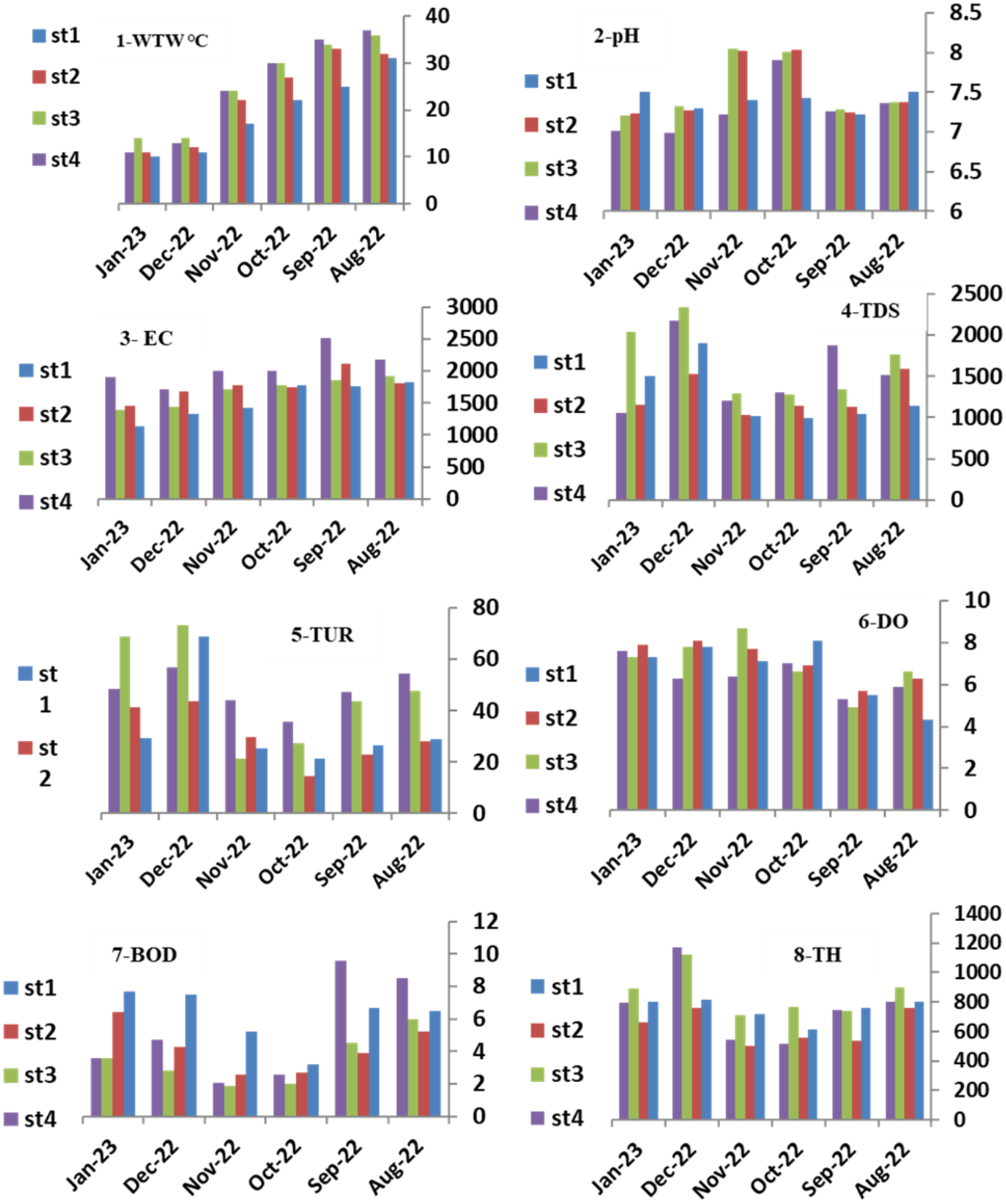


Figure 1. Study sites on Al-Sabil River.

Temperature is important for water quality because it affects the solubility of minerals and gases affecting the distribution and physiology of aquatic organisms (Hoosier, 2000).

The pH has recorded the lowest rate of 7.29 (site 4) and the highest rate of 7.545 at site 3 (Table 1). The lowest value was 6.99 in December 2022 (site 4), and the high value was 8.05 in November 2022 (site 3) (Fig. 2). This value was within the Iraqi standards for water quality in 1998, and the maintenance of the Iraqi river system in 1967. The pH values were slightly alkaline in all studied sites. It is a common characteristic in Iraqi internal waters (Hashim and Rabee, 2014).

The lowest rate of EC was recorded at 1543 µs/cm (site 1), and the highest one was 2050 µs/cm in site 4


1-WTW °C
st1
st2
st3
st4
40
30
20
10
0
Jan-23
Dec-22
Nov-22
Oct-22
Sep-22
Aug-22
2-pH
8.5
8
7.5
7
6.5
6
3- EC
3000
2500
2000
1500
1000
500
0
4-TDS
2500
2000
1500
1000
500
0
5-TUR
st 1
st 2
80
60
40
20
0
6-DO
10
8
6
4
2
0
7-BOD
12
10
8
6
4
2
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8-TH
1400
1200
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400
200
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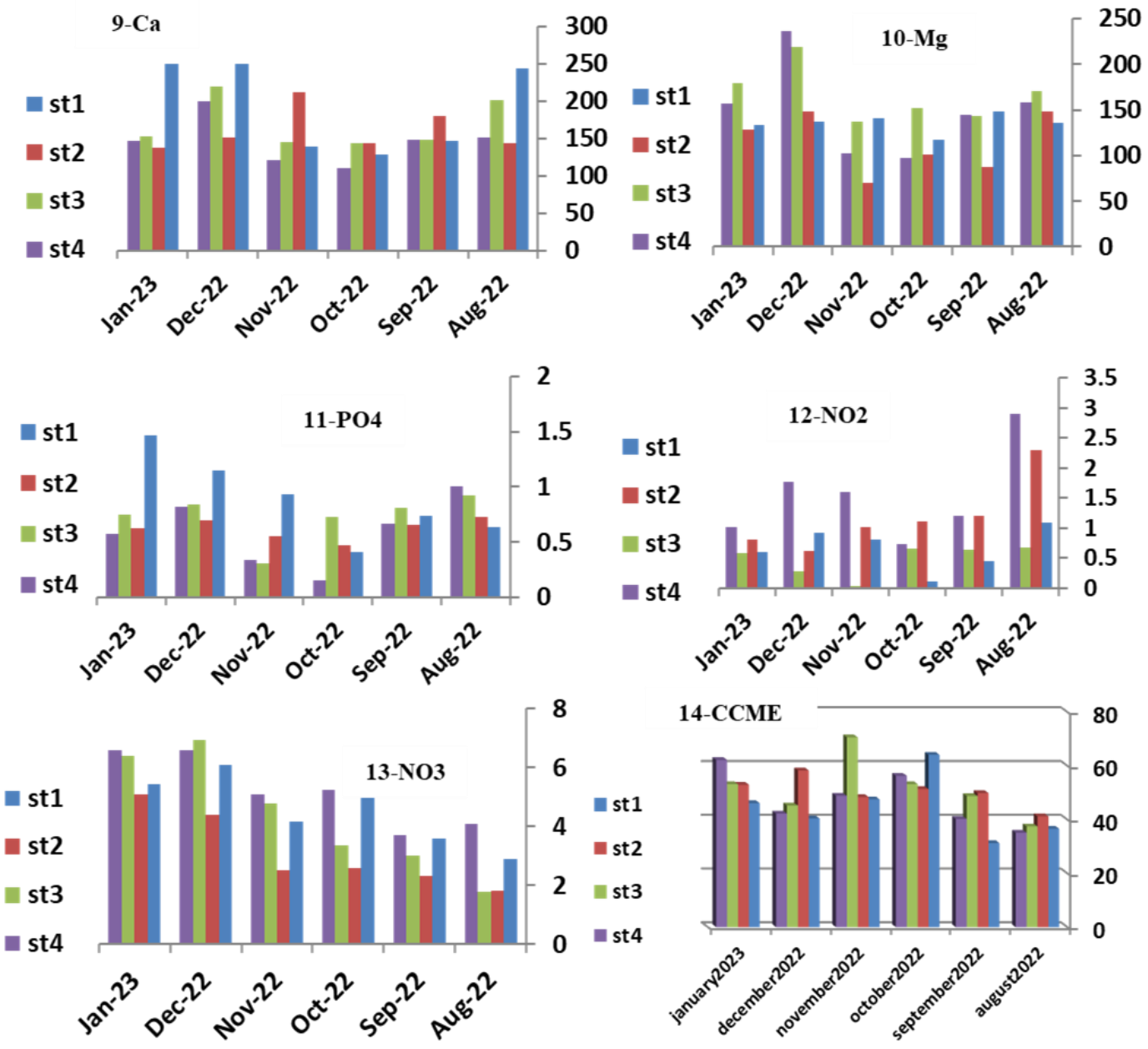

Figure 2. The physical and chemical properties and the values of the Canadian water quality index during the study period on the Al-Sabil River from August 2022 to January 2023. (1) water temperature, (2) pH, (3) electrical conductivity, (4) solids total dissolved, (5) turbidity, (6) dissolved oxygen, (7) BOD, (8) total hardness, (9) calcium, (10) magnesium, (11) phosphate, (12) nitrite, (13) nitrates, and (14) water quality index Canadian index.

(Table 1). In January 2023 was a low value in site 1, while the highest value during September 2022 was in site 4 (Fig. 2). The higher EC may be due to precipitation and entering of salts from the area surrounding area of river, and the discharge of sewage or other pollutants (Welcomme, 1979). These values were similar to some previous studies on the Euphrates River (Al-Khaledy, 2003; Al-Sarraf, 2006). The lowest rate of total suspended solids (TDS) was 1261 mg/L in site 2 and the highest was 1676 mg/L in site 3 (Table 1). The low TDS was found during October 2022 in site 1, and the high value in site 3 during December 2022 (Fig. 2). The high value may be attributed to the abundance of rainfall. These TDS values exceeded the Iraqi standards for water quality in 1998. It is a measure of inorganic, organic, and other dissolved substances in water (Al-Kenzawi et al., 2011).

The lowest rate of turbidity (TUR) was 30.1 NTU in site 2, and the highest rate was 47.78 NTU in site 4 (Table 1). TUR had a low value in November 2022 at site 3, and the highest value was in December 2022 at site 3 (Fig. 2). The reason for the high turbidity values is due to the large values of suspended matter and untreated sewage water discharged directly into the river (Al-Tamim and Braak, 2019; Al-Tamimi and Al-Obeidi, 2021). The lowest rate of DO was 6.417 mg/L in site 4, and the highest rate was 7.1 mg/L in site 2 (Table 1). The low values of DO in site 1 during August 2022 may be due to the decomposition of organic materials that are discharged into the river through sewage, and a rise in temperature to 37°C, which leads to a decrease in the concentration of DO in the water. The high values of DO in site 3 during November 2022 (Fig. 2) may be attributed to the increase in precipitation in addition to the decrease in temperature in winter, which increases the solubility of oxygen (Adeyemo et al., 2008). In addition, the increase in water during the winter season has a major role in raising the concentration of dissolved oxygen (Tobin et al., 2001; Al-Nashi and Alakum, 2013; Al-Sarraj, 2019).

The BOD was recorded as 3.467 mg/L in site 3 and the highest rate as 6.133 mg/L in site 1 (Table 1). It was high during September 2022 in site 4, and the lowest value was in November 2022 in site 3 (Fig. 2). The increase of BOD during the summer in the Al-Sabil River is related to the organic matter originating from wastewater and industrial and agricultural areas (Chapman, 1992; Hashim, 2017). The lowest total hardness (TH) rate of 630 mg/L was recorded in site 2 and the highest was 853.3 mg/L in site 3 (Table 1). TH during the study period on the Al-Sabil River had high values in site 4 in December 2022, and low values in site 2 in November 2022 (Fig. 2). The lowest rate of calcium was 146.3 mg/L in site 4 and the highest rate was 192.7 mg/L in site 1 (Table 1). The high values of Ca during the study period were during December 2022 in site 1, and the low values in October 2022 in site 4 (Fig. 2).

The lowest rate of Mg was 113.9 mg/L in site 2, and the highest rate was 166.4 mg/L in site 3 (Table 1). The high value of Mg during the study period was in Site 4 in December 2022, and the low value was in November 2022 in Site 2 (Fig. 2). The high rates of total hardness, calcium, and magnesium may be due to the increase in rainfall and the leaching of large quantities of pollutants into the riverbed, in addition to sewage and agricultural effluents from homes and farms close to the river (Hashim, 2017; Muhammad, 2019; Al-Shujairi, 2021). The lowest rate of phosphate was 0.591 mg/L in site 4, and the highest rate was 0.887 mg/L in site 2 (Table 1). Phosphate values in the Al-Sabil River water ranged from the lowest value in October 2022 at Site 4 to the highest value during January 2023 at Site 1 (Fig. 2). Phosphate concentrations increased during December 2022 and January 2023 at site 1 and decreased during October and November 2022 at site 4 (Al-Hajimi, 2014).

The lowest rate of nitrite 0.486 mg/L was recorded in site 3 and the highest rate of 1.539 mg/L in site 4 (Table 1). Nitrite values ranged from the highest value in November 2022 at site 3, to the highest value during August 2022 at site 4 (Fig. 2). The results showed that the increase in NO_2 in some months is due to the lack of phytoplankton, or it may be attributed to the decomposition of organic matter at high temperatures (Al-Shaaban, 2021). The lowest rate of nitrates 0.486 mg/L was recorded in site 2 and the highest rate was 1.539 mg/L in site 4 (Table 1). The nitrate values ranged from the lowest value during August 2022 at Site 3 to the highest value during December 2022 (Fig. 2). The increase in nitrate values during the growing seasons may be due to the use of nitrogen fertilizers by farmers, or due to bacterial activity that converts nitrites into nitrates and the decomposition of organic compounds. The low values of nitrates are attributed to their consumption by phytoplankton and the reduction of nitrates to nitrites (Allen, 2011; Salman and Hussain, 2012).

Water Quality Index Canadian Index: The results of CCME WQI showed the lowest rate as 44.35 in site 1 and the highest rate as 51.41 in site 3. It showed the lowest value of 31.303 i.e. poor condition in September 2022 in site 1, and the highest acceptable value of 70.61 in fair condition was in November 2022

in site 3 (Fig. 2). It may be attributed to the high percentage of TDS, turbidity, and BOD, TH, Ca, phosphate, and nitrate. Also, the increase of most of the selected variables in the Canadian Model Water Quality Index (CCME WQI) international determinants for living aquatic organisms due to pollutants from sewage and domestic water and drains returning to the river from agricultural areas (Hassan et al., 2018; Al-Ghanmi, 2015).

Conclusion

The water quality of the Al-Sabil River is affected by the high rates of TDS, TUR, BOD, TH, Ca, PO_4, and NO_2 significantly based on the values of the Canadian Model Water Quality Index (CCME WQI). This is because of exposure of the river water from sewage and water from nearby agricultural lands. The water quality index values of the Canadian model exceeded the international determinants for organisms.

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