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Assessment of Water Quality Using Organic Pollution Index in Some Marshes North of Basra Province

Azhar Nazal Makki[1], Dunya A. H. Al-Abbawy[2] and Naeem S. Hammadi[3]

[1,3]Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah, Basra, Iraq.
[2]Department of Ecology, College of Science, University of Basrah, Basra, Iraq.

[2] E-mail: dunya.hussain@uobasrah.edu.iq

Abstract. The organic pollution index (OPI) was applied to assess the state of the organic pollution in the southern part of Eastern Hammar marsh, Al-Chebiyesh marsh, and the Euphrates and explain the role of submerged aquatic plants in reducing the level of water pollution. Water samples were collected monthly from two stations for each part (i.e., with and without submerged plants). The OPI depended on three parameters, namely, NO_3, PO_4, and BOD_5. Results show that the highest NO_3 was 6.4 mg/L in February in Al Burka, whereas the lowest value was 2.3 mg/L in August in the Euphrates station, which contains submerged plants. The highest PO_4 was 0.76 mg/L in February in Al Burka, whereas the lowest value was 0.24 mg/L in August in Saleh River's station, which contains submerged plants. The highest BOD_5 was 3.63 mg/L in August in the Al Burka station, whereas the lowest value was 0.91 mg/L in February in the Euphrates station, which contains submerged plants. The index values indicate the presence of organic pollution in all stations, with discounts varying between (65.9 and 36.2), (49.9 and 35), and (40.1 and 22) in Eastern Hammar, Al- Chebiyesh, and the Euphrates, respectively. The vital role of submerged plants in the consumption of nutrients reduced the OPI annual values to (44.4, 37.8, and 25.3) compared with the values in stations without plants (54.9, 44.6, 36). The annual values varied between the Deteriorated category in the East Hammar marsh, a Poor category in Al-Chebiyesh, and the Medium category in the Euphrates, with yearly values of 49.7, 41.2, and 30.7, respectively.

Keywords. Basra wetlands, OPI Index, Nutrient, Submerged plants.

1. Introduction

Determining the pollution status is one of the first steps in monitoring and preventing water quality degradation [1]. Surface water quality is being challenged as economic growth, demographics, and climate change lead to widespread and severe degradation. Water is typically considered polluted when anthropogenic contaminants impair it. These contaminants either do not support human use, such as drinking water, or undergo a marked shift in their ability to support their biotic communities [2]. Pollution represents a severe problem in the environment. Organic pollution is used when large amounts of organic compounds are present. Domestic sewage, urban runoff, industrial effluents, and agricultural wastewater arise. In wastewater treatment plants and industries, these pollutants enter the aquatic environment by releasing effluents from these activities [3].

The organic pollution index (OPI) is a comprehensive index that includes more water quality constituents than standard values and combines several pollutants in the same property [4]. Many studies, such as [5-9] have been conducted to assess the levels of organic pollution for some water bodies.

Several studies were performed to evaluate the contamination of some water bodies. For example, [10] described the waters of the central part of the Shatt al-Arab as weakly polluted or not organically polluted. [11] showed the presence of monthly fluctuations in the values of the OPI in the Shatt al-Arab, Al-Ashar Canal, and the confluence of the Tigris and Euphrates rivers in Al-Qurna. [12] stated that the presence of high-density vegetation cover in some stations in southeast Hammar marsh played a vital role in reducing the OPI value, which amounted to (24.60) compared with stations without it with a value of (82.68). [13] cited that power generation plants had a clear impact on the water quality of the Shatt al-Arab River and its suitability for various purposes under a high level of organic pollution during the summer and winter seasons indicated the quality of the Shatt al-Arab waterfalls. [14] evaluated the organic pollution of Shatt al-Arab water from 2017 to 2018 through the three stations of Al-Dweab, Al-Sharash, and Al-Salhiya. As observed from the results, the water was organically polluted, and Al-Salhiya is the worst polluted station. [15] evaluated the Euphrates River's organic pollution levels in southern Iraq quantitatively and descriptively to indicate its feasibility for domestic, industrial, and agricultural uses. [16] applied the OPI index for the descriptive and quantitative assessments of the levels of organic contamination for Al- Chebiyesh marsh and showed that the most controlling factors in the OPI index were NO_2 and NH_4 ion, followed by BOD_5 and PO_4.

This study aims to assess the water quality of some wetlands in Basra Province by using the OPI index and explaining the role of submerged aquatic plants in improving water quality.

2. Materials and Methods

2.1. Description of the Study Area

Eastern Hammar marsh is one of the three main marshes in southern Iraq. It is the largest one among them. It is located to the right part of the Euphrates River, extending from the Thi-Qar province in the west to the outskirts of Basra province in the east. Across the Shatt al-Arab, the water depth varies in different regions. It ranges between 0.3 m and 2.5 m during the tide. Two sites were selected: S1, or fishing activities and herding buffalo characterize Al Burka; and S2, or Mniassfa, located the north of S1. The average distance between them is 4 km, characterized by the shallower depth that ranges from 32–100 cm and is unpopulated.

Chibayish marshes are one of the most famous central marshes spread in a triangular depression between the provinces of Thi-Qar and Basra. The marshes vary seasonally depending on the flow of water from the Euphrates River. Two sites situated on the left of the south Euphrates River were selected. S3 is represented by the Abu-Alsabaa, one of the hydraulic stations established by the Marsh Revitalization Center to feed the central marshes. The water depth ranges from 1.75 m to 6.5 m. They are characterized by submerged aquatic plants, such as *Ceratophyllum demersum* L., *Najas marina* L., and *Ruppia maritime*, and emergent plants, such as *Phragmites australis* and *Typha domingensis*. Inhabitants of few population centers practice the professions of fishing and animal husbandry. S4 is about 1 km away from S3, and the absence of aquatic plants is compared with S3.

Euphrates River is one of the two main rivers considered an essential source of surface water in Iraq and freshwater for humans and provides the water needed for irrigation.

S5 or Saleh River is located in the southern section of the Euphrates River near the village of Al-Shutayt, about 11 km from the Almduaina center in northwest Basra Province after the Euphrates Dam. The water depth ranges between 2 m and 3 m; the average width is 500 m, the intensity of submerged plants is high, and the average current velocity is 0.23 m/sec. Fishing operations characterize S5. S6 is located 8 km away north of S5. Both stations are characterized by high water transparency, which reaches 218 cm.

Table 1. Location of the sampling area.

Position	Station name	GPS
Eastern Hammar marsh	S1	N: 30°41'45.87" E: 47°32'59.56"
	S2	N: 30°41'22.16" E: 47°37'4.78"
Al- Chebiyesh marsh	S3	N: 30°59'3.45" E: 47° 8'39.80"
	S4	N: 30°58'51.04" E: 47°10'47.90"
Euphrates River	S5	N: 30°57'7.18" E: 47° 9'2.74"
	S6	N: 30°57'8.88" E: 47° 7'42.81"

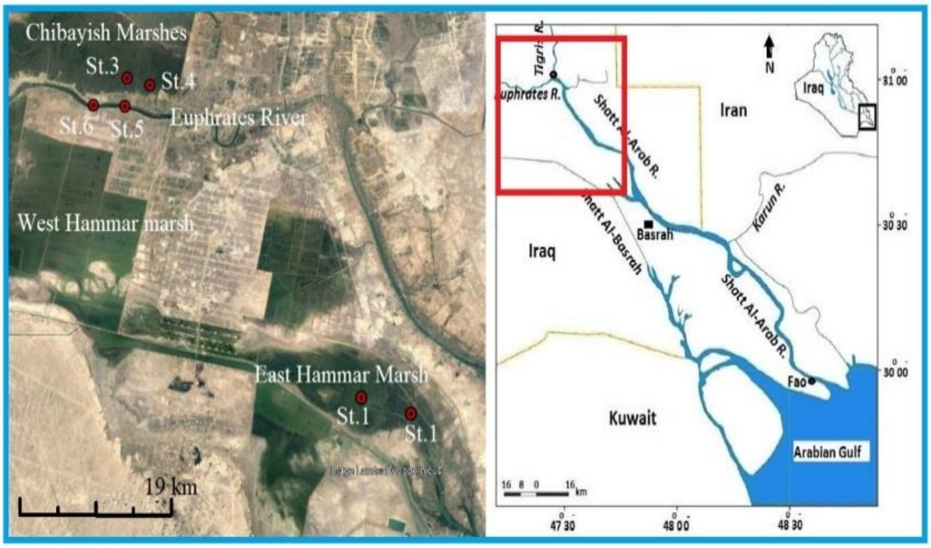

Figure 1. The Map of study area.

2.2. Water Sample Collection

Water samples were collected monthly from November 2020 to October 2021 from 20–30 cm under the water surface. Temperature and pH were measured in the field using a multimeter instrument. The OPI index was calculated, and the variables, such as NO_3, PO_4, and BOD_5, were adopted. According to [17], the variables were measured and calculated depending on the following equation [18].

$$OPI = (\Sigma\, Ci / Cmi) / n \times 10$$

where:
Ci: are the monitored pollution concentrations.
Cmi: the guidelines stand for the maximal amount of permitted pollution content.
N: the number of variables used to calculate the index
The data were tested using the SPSS software program for analysis. All means were tested under 0.05.

Table 2. Grid evaluation of organic pollution.

Limits	Pollution level Organic
<9	None
10-29	Weak
30-39	Medium
40-49	Poor
50-59	Deteriorates
60-69	Bad

3. Results

3.1. Water Temperature

Fig. (2), Showed monthly variations of the water temperature in the stations varied with time; they ranged from 13 °C in February to 33 °C in August.

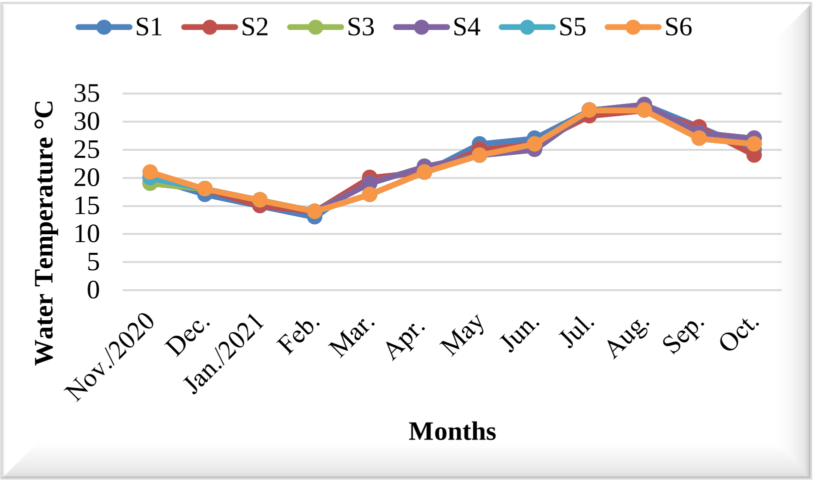

Figure 2. Monthly variations of the temperature °C.

3.2. Potential of Hydrogen Ions (pH)

Fig. (3) explained that values were on the alkaline side, and they ranged between (7.8, 8.5), (7.7, 8.4), and (7.7, 8.5) in Eastern Hammar, Al- Chebiyesh, and the Euphrates, respectively. A non-significant difference was observed among stations ($p > 0.05$).

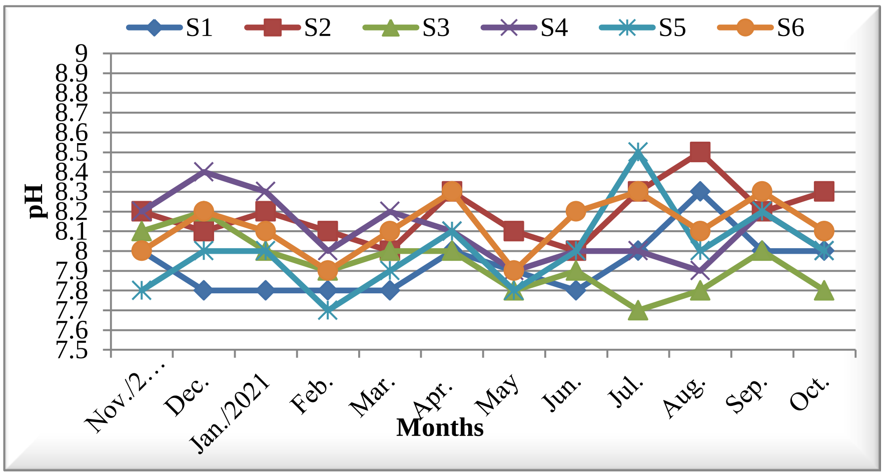

Figure 3. Monthly variations of pH.

3.3. Nitrate(NO3-)

The disparity in the NO_3 values in Eastern Hammar, with an average value of (5.01) mg/L, ranged between 3.33 mg/L and 6.4 mg/L in August and February, respectively. In Al- Chebiyesh, the values went between 3.21 mg/L and 5.54 mg/L in August and February, with an average value of (4.3) mg/L, respectively. In the Euphrates, the values with an average (3.32) mg/L ranged between 2.3 mg/L and 4.82 mg/L in December and October, respectively Fig.(4). Statistical analysis showed a significant difference ($p \leq 0.05$).

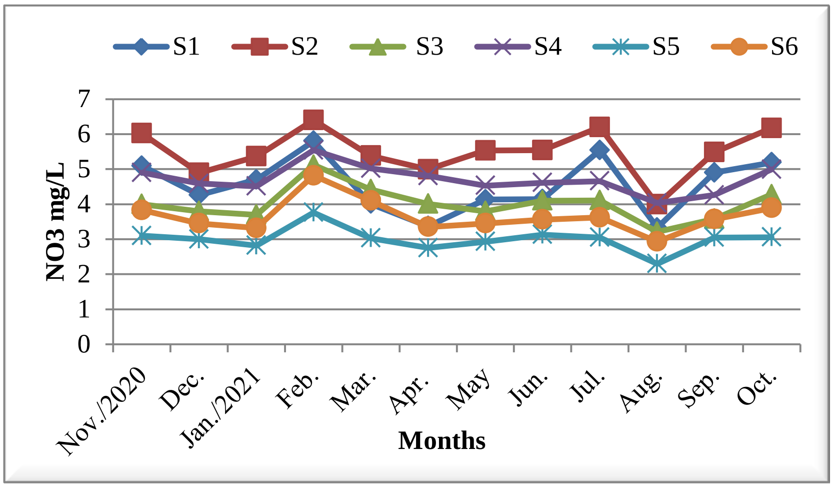

Figure 4. Monthly variations of the Nitrate NO_3.

3.4. Orthophosphates Phosphate ($PO4^{-3}$)

values, as the lowest and highest values, ranged between (0.4-0.76) mg/L in August and February in Eastern Hammar and (0.39-0.57) mg/L during August and February in Al- Chebiyesh while (0.24-0.46) mg/L in the Euphrates in August and while highest value recorded in February. The general average was 0.56, 0.46, and 0.34, respectively Fig. (5). The difference ($p \leq 0.05$) between stations was insignificant.

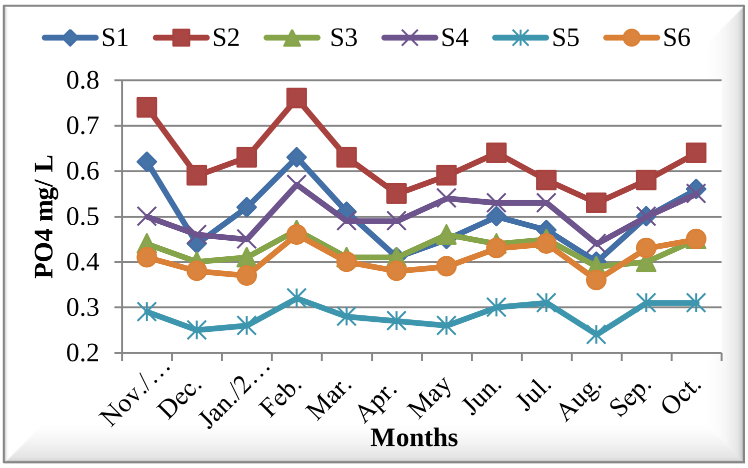

Figure 5. Monthly variations of Orthophosphates PO_4.

3.5. Biological Oxygen Demand (BOD_5)

The levels of BOD_5 reflect the load of organic matter. The results show that they sometimes decrease or increase depending on the values of NO_3 and PO_4. The lowest and highest values (1.5–3.63 mg/L) were observed in February and August in Eastern Hammar; (1.18-2.93 mg/L) in February and August in Al- Chebiyesh; and (0.91–2.29 mg/L) in February and August in the Euphrates Fig. (6). A non-significant difference ($p > 0.05$) was observed among the stations.

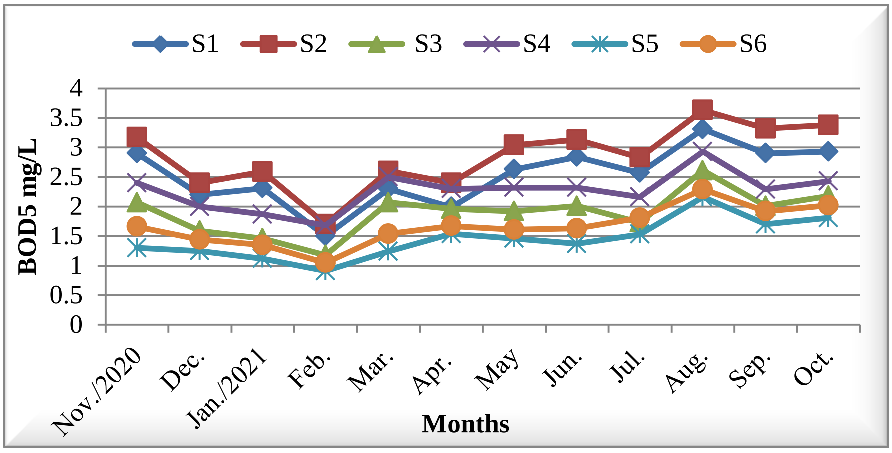

Figure 6. Monthly variations of BOD_5.

3.6. Organic Pollution Index

Values in stations that contain plants were (54.8, 41.1, and 28.1) in February, whereas the lowest values were (36.2, 35, and 22) in August. The highest index values in stations without plants were 65.9, 49.19, and 40.1 in February. In contrast, the lowest values were 47.5, 39.5, and 32.2 in August, Fig (7). Statistical analysis showed insignificant differences among the stations ($p < 0.05$).

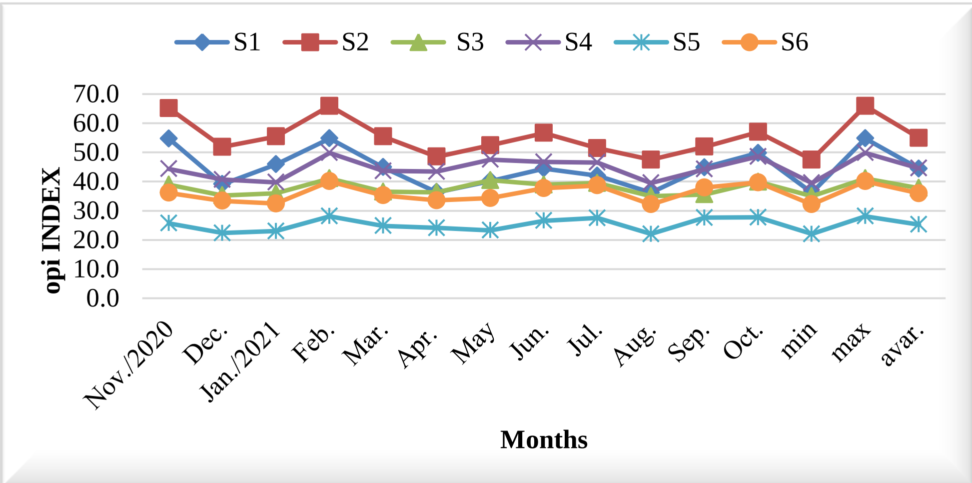

Figure 7. Monthly variations of the OPI index.

3.7. Organic Pollution Index

Values varied considerably during the studied periods and stations; they fluctuated between (36.2 and 65.9) in August and February in Eastern Hammar Fig. (8). Statistical analysis showed insignificant differences among the stations ($p < 0.05$).

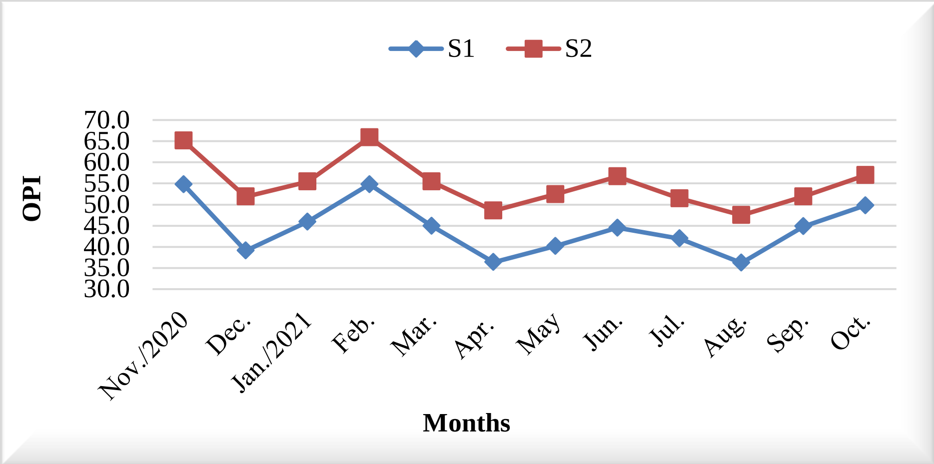

Figure 8. Monthly variations of OPI Index at S1, S2.

Fig. (9). Showed monthly variations of OPI Index in Al- Chebiyesh which ranging between (35 and 49.9) in August and February.
The value of OPI Index ranging between (22 and 40.1) in August and February in the Euphrates, Fig (9). The difference ($p \leq 0.05$) between stations was insignificant

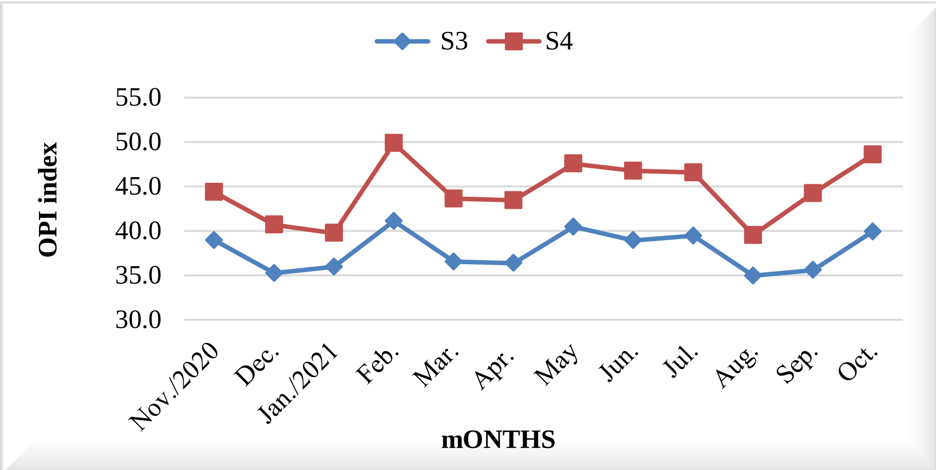

Figure 9. Monthly variations of OPI Index at S3, S4.

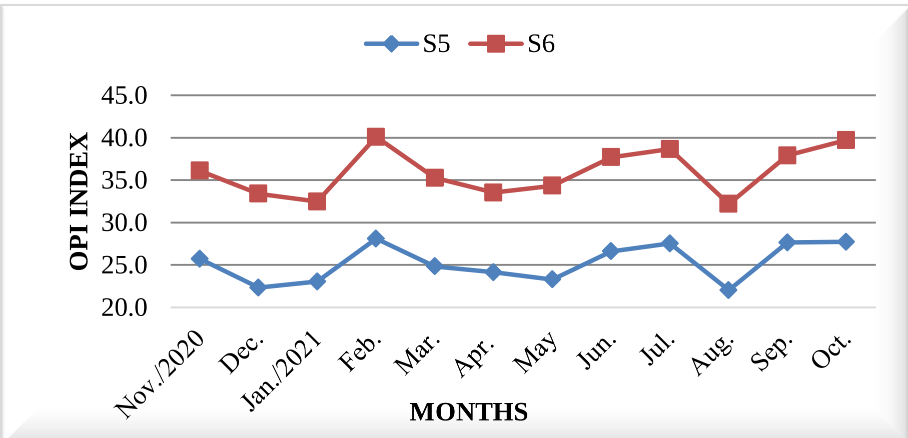

Figure 10. Monthly variations of OPI Index at S5, S6.

The value of OPI Index ranging between (22 and 40.1) in August and February in the Euphrates, Fig (10). The difference ($p \leq 0.05$) between stations was insignificant.
The annual rate of the OPI Index in stations that contain plants were (44.4, 37.8, and 25.3) while the annual rate in stations without plants were (of 54.9, 44.6, and 36) for the Eastern Hammar, Al-Chebiyesh, and the Euphrates, respectively (Fig. 11).

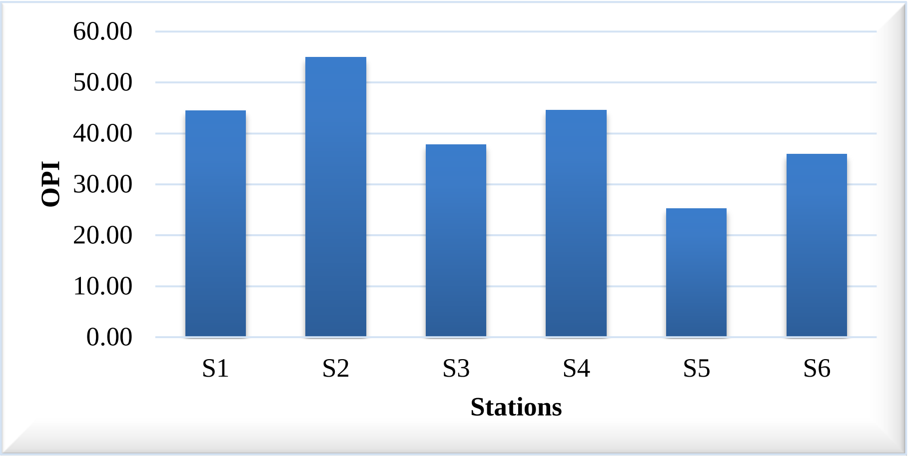

Figure 11. Annual rates of the OPI Index for all stations.

The annual OPI index rate for the three environments is 49.7, 41.2, and 30.7 (Fig. 12). Statistical analysis showed insignificant differences among the stations ($p< 0.05$).

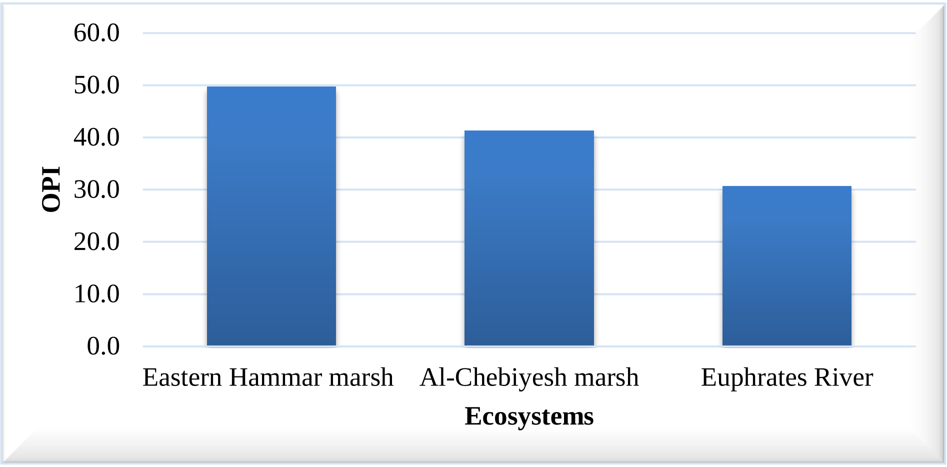

Figure 12. Monthly variations of the OPI index at three Ecosystems.

4. Discussion

Nutrients have a positive role in wetlands because they catalyze the growth of phytoplankton and aquatic plants. However, this role is negative if their concentrations exceed their standard limit, thereby causing a state of eutrophication [19]. The nitrate and phosphate values varied during the study period and in all stations because they did not adopt a specific pattern. This finding may be related to the varying concentrations of pollutants caused by agricultural activities and population centers [20]. Furthermore, it changes with months and seasons [21]. The nitrate and orthophosphate values in stations that include submersible aquatic plants were generally lower than those without them because of the plant's ability to remove nutrients from the water. It contains the values of nutrients; submerged macrophytes can potentially take up nutrients from the entire water column [22], and plants can remove up to 30% of orthophosphate from the water column by direct assimilation [23]. Moreover, oxidation of sediments increases their ability to bind with inorganic phosphorous, thus reducing the release of orthophosphate in the water column [24].

The biological oxygen demand (BOD_5) refers to the amount of dissolved oxygen required by microorganisms to decompose organic matter under aerobic conditions. BOD_5 is used as a way of referring to organic pollution in water. The more organic matter is present in the water, the more oxygen is required, so BOD_5 levels increase [25].
The values of the BOD_5 corresponded with nitrate and orthophosphate values during the study period. The concentration of BOD_5 is based on Class II quality standards. The greater concentration indicates that the water has been polluted, so waters can be categorized as good when having BOD_5 levels that range from 0 to 3 mg/L, whereas that with a BOD_5 concentration of more than 3 mg/L is considered contaminated [26].
The results indicated that the pollution levels determined based on the OPI index fluctuated during the study period in all stations could be due to fluctuations in the environmental conditions of these stations. The highest values were recorded in the Eastern Hammar Marsh (54.8, 65.9) in S1 and S2 in February, respectively. Such value is classified under the fifth category as Deteriorated Organic Pollution (49.7) because of its impact on the tidal water that comes from the Shatt Al-Arab River and its nutrients, as well as the importance of the depth factor of the water column in the richness of shallow environments with nitrogen and phosphorous as a result of mixing sediments [19], which contributed to the increase in the values of the factors that affect the evidence (nitrate and orthoPhosphate) and thus the increase in the values of the index.
The southern part of the Al-Chebiyesh marshes was characterized by a somewhat better water quality than that of Eastern Hammar. The highest values were recorded (41.1, 49.9) in S3 and S4, respectively. Such value is classified under the fourth category as Poor Organic Pollution (41.2) because it is a non-tidal marsh. The water that comes from the Euphrates River improved the water quality. However, the results of the current study showed a deterioration in water quality; it was classified in a medium category compared with a previous study27 [27], which ranked it under a weak class, and the reason may be attributed to the low levels of water that flows to it from the Euphrates River, especially in the last months of the study.
The water quality of the southern part of the Euphrates River is the best among the three environments. The highest values were recorded (28.1, 40.1) in S5 and S6, respectively. Such value is classified under the third category as Medium Organic Pollution (30.6). This result may be due to an increased underwater light field that increased the density and efficiency of submerged plants to perform photosynthesis, thereby consuming nutrients and reducing evidence values. The vegetation cover and its ability to photosynthesize increase with high transparency [28]. In general, the index values at stations characterized by the presence of submerged plants were lower than those without them because of the role of plants in absorbing nutrients, nitrates, phosphates, and other elements during their growth process, thereby removing nutrients from the water, and this ability is increased by the synergistic effects of the microbial activity of multiplying microorganisms on the plant [29,30,31].
Inorganic nutrients are transformed into organic matter through photosynthesis while becoming food for consumers [32]. Aquatic plants are essential in cleaning the environment and maintaining water health. It uses environmentally sound technologies due to its large vegetation cover and high productivity [33]. It also improves the characteristics of water and its disposal of different pollutants [34], leading to the normal functioning of the ecosystem and increasing its resources. Moreover, many countries of the world have resorted their wetlands to using these inexpensive technologies to face many environmental problems by creating constructed wetlands or depending on natural wetlands.

Conclusion

The present study showed the pollution of the study stations in varying proportions caused by changing environmental conditions. Submersible aquatic plants had a role in reducing organic pollution compared with stations without them.

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