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Detecting the Deterioration of the Water Quality of the Shatt Al-Basrah Canal Using Nutritional and Pollution Indicators

Zahraa Jassim Mohammed Al-Joubory[1] and Maitham Abdullah Al-Shaheen[2]

[1,2]Department of Ecology, Collage of Science, University of Basrah, Basrah, Iraq.

[1]E-mail: zahraa.jassimm@uobasrah.edu.iq
[2]E-mail: maitham.alshaheen@uobasrah.edu.iq

Abstract. Owing the scarcity of research using environmental and pollution indicators to study the water quality of the Shatt Al-Basrah Canal, our current research aims to fill this gap. This study aimed to assess the water quality of the Shatt Al-Basrah Canal by applying a set of environmental and pollution indicators, including the Trophic Status Index (TSI), Trophic Level Index (TLI), Trophic Index (TRIX), Organic Pollution Indicators (OPI), and River Pollution Index (RPI). These indicators were selected because of their ability to transform the results of several different and complex environmental factors into simple, meaningful numbers that reflect the environmental status of the targeted water body. Water samples were collected quarterly from April 2024 to February 2025 from three selected locations along the canal to account for pollution sources. The samples were analyzed for a wide range of physical, chemical, and biological parameters. The results showed a significant deterioration in the water quality of the Shatt Al-Basrah canal, with all stations being highly nutrient-rich. All stations were also heavily polluted and had poor water quality, according to the pollution index classification. This is due to the impact of untreated sewage and agricultural and industrial pollutants, which contribute to the deterioration of aquatic life and the overall environmental health of the canal's water system. These results are of particular importance for specialists and government agencies responsible for water resources and the environment to highlight the development of environmental policies and river water management in southern Iraq, particularly in the Basrah Governorate.

Keywords. Shatt Al-Basrah Canal, Water Quality, Organic Pollution, Nutritional Indicators.

1. Introduction

The Shatt Al-Basrah Canal is one of Iraq's artificial inland waterways. It connects the main estuary, or Third River, on one side, and the Khor al-Zubair River on the other, thus linking the marshes of southern Iraq to the Arabian Gulf. As a canal, it initially served to drain agricultural lands and acted as a natural drainage channel for treated and untreated wastewater from residential and industrial sources. The primary objective of digging the Shatt Al-Basrah Canal was to relieve the burden on Shatt Al-Arab river during the flood season and to drain the drainage water from the agricultural lands located between the Tigris and Euphrates rivers. It was also used as a navigational canal for river transport, particularly during the Iran-Iraq War in the 1980s.

However, over the past two decades, the Shatt Al-Basrah Canal has faced increasing environmental pressures due to rapid urban expansion in the Basrah Governorate, as well as the lack of effective

wastewater treatment plants. This has led to the discharge of untreated domestic wastewater, effluent from the Basrah oil refinery, and fertilizer-laden agricultural runoff, significantly affecting the physical and chemical composition of the canal. Numerous environmental studies have documented sharp increases in nutrient and pollutant concentrations, particularly ammonia, nitrates, phosphates, and heavy metals such as lead, cadmium, and mercury, exceeding international and national permissible limits [1-3]. The combined effect of this situation has led to environmental degradation of the Shatt al-Basra Canal and serious environmental consequences, including over eutrophication, loss of aquatic biodiversity in the canal, and potential health risks for communities that rely on the river for fishing and water buffalo farming. Therefore, the current state of the Shatt al-Basra Canal requires urgent scientific environmental assessment and government intervention to prevent further environmental degradation and to restore its ecological integrity.
Although numerous studies have assessed the overall water quality status of the Shatt Al-Arab river and Marshlands [4-8], there is a marked lack of focused research specifically targeting the Shatt Al-Basrah Canal, which is waterway hydrologically and ecologically distinct from Shatt Al-Arab river. Despite its importance, the Shatt al-Basra Canal has not received significant scientific attention as it has an impact on decision-making. Existing studies have often focused on general findings at the canal system level, the canal's unique hydrological characteristics, and the increasing human pressure. Furthermore, there remains a significant lack of continuous environmental monitoring and long-term water quality monitoring in the canal area, hindering the development of effective environmental management strategies. In particular, multiple environmental indicators, such as the trophic status index (TSI), trophic level index (TLI), trophic index (TRIX), organic pollution index (OPI), and river pollution index (RPI)—have rarely been applied to this specific site. This research seeks to fill this critical gap by systematically assessing key pollution indicators, examining spatial and temporal variations, and providing a more accurate understanding of the canal's current environmental status. It aims to inform targeted remediation efforts and contribute to evidence-based solutions to problems in the region.

1.1. Previous Studies on the Shatt Al-Basrah Canal
Numerous multidisciplinary scientific studies have been conducted on the Shatt Al-Basrah Canal, focusing on measurements of physical and chemical environmental factors, as well as various other factors such as fish, algae, plankton, fecal bacteria, invertebrates, and other aquatic organisms. [9-12]. Several local studies have investigated the physicochemical characteristics of the Shatt Al-Basrah Canal and revealed a consistent pattern of environmental degradation attributed to anthropogenic pressures.
The water quality in the canal was poor compared to that in the Shatt Al-Arab River and marshes, especially in the field of environmental indicators, particularly in the field of environmental indicators. Hamza and Sadkhan [13] studied the physical and chemical factors of the Shatt Al-Basrah Canal's water. Physically, dissolved solids were measured, whereas chemical variables included pH, dissolved oxygen, alkalinity, total hardness, calcium, magnesium, nitrate, nitrite, and phosphate. All variables were outside the permissible limits for drinking water, and they were considered unsuitable for food industries, fish habitats and reproduction, but were suitable for agricultural purposes at almost all stations. The results of this study were consistent with those reached by Al-Safi [14] except for the suitability of the water for fish to live and reproduce at almost all stations.
Haneff et al. [10] conducted an environmental and bacteriological study on the Shatt Al-Basrah Canal, collecting samples during April and May 2013. The results showed that sanitary and industrial wastewater always lead to a significant increase in most of the environmentally hazardous determinants and this water is not suitable for human use. This result is also consistent with Mustafa's study [15], as water was hard and unfit for human and food use.
In a recent study, Al-Mahmoud et al. [16] evaluated the characteristics of the Shatt Al-Basrah Canal water and compared them with permissible limits according to the standard specifications for drainage water. The aim of this study was to assess the level of water degradation in the Shatt Al-Basrah Canal and to determine the water classification based on the severity of the measured pollution. The physical and chemical characteristics of water were measured during the dry and rainy seasons of 2022 and

2023, respectively, at three selected locations in the canal. These characteristics include salinity, electrical conductivity, total dissolved solids, and physical and chemical parameters. Based on the Canadian model, the results showed that the Shatt Al-Basrah Canal water falls into the severely degraded category, which is the last “severe category” of water pollution.

As for the use of environmental and pollution Indices, it is rare in the Shatt Al-Basrah Canal. Hassan et al. [17] applied the Water Pollution Index (WPI) to the waters of the Shatt Al-Basrah Canal during 2014-2015. It indicated that the water was unsafe and unfit for drinking, falling within the categories of “impure” to “very impure”.

On the other hand, the spatial variation of organic pollution in the waters of the Shatt Al-Basrah canal was applied using organic pollution indicators (OPI), and the results showed that the waters of the first four stations suffer from organic pollution (Where these stations are located north of the regulator and in direct contact with pollution sources - sewage water), with the exception of the fifth and sixth stations, which are located south of the regulator and in direct contact with marine waters far from pollution sources [18].

The TSI index was applied by Galo and Resen [19] at two stations at in the Shatt Al-Basrah canal; the first one is near the Shatt Al-Basrah gas power station, while the second is near the Shatt Al-Basrah regulator. The results of the TSI index showed that the category of the first station was in the medium nutritional status, while the second station was within the high trophic state.

This study addresses these research gaps by employing a multi-index, data-driven approach that combines international environmental assessment frameworks with seasonal sampling and spatial mapping. Through this methodology, the research not only evaluates the water quality of the Shatt Al-Basrah Canal with high precision but also attempts to trace pollution patterns back to specific human activities, thereby enhancing the utility of the findings for both scientific understanding and environmental policymaking. This integrative framework is intended to support more effective decision-making and contribute to the development of sustainable water management practices tailored to the unique environmental challenges of southern Iraq.

2. Materials and Methods

2.1. Study Area

The Shatt Al-Basrah Canal is an artificial waterway connected to the Main Outfall Drain (MOD) (called the Third River) and Garmat Ali Canal, northwest of the Basrah Governorate. It runs east of the Al-Zubair District until it flows into the Khor Al-Zubair lagoon, where the Shatt Al-Basrah Regulator was built. The purpose of digging the Shatt Al- Basrah Canal was to relieve the burden on Shatt Al-Arab River during the flood season, to drain the agricultural lands confined between the Tigris and Euphrates rivers, and to be used as a navigational canal for river transport. The geographical boundaries of Shatt Al-Basrah Canal are limited to two extensions. The first extends from the Balance Basin or Balance Lake, which is part of the general estuary and is currently the northern beginning of the Shatt Al-Basrah Canal. The other extension was located 22 Km from the head of the canal (from the point where the Shatt Al-Basrah branches off from the Garmat Ali Canal). It was established as a flood regulator, and at that time the Shatt Al-Basrah Canal began from the Garmat Ali Canal to control water levels. This branch is currently closed in the Harir region (Figure 2). Therefore, Shatt Al-Basrah Canal is not connected to the waters of the Garmat Ali canal, but rather to the branch connected to Balance Lake (the Balance Basin) [16].

The total length of the canal is approximately 42 km between the MOD and Khor Al-Zubair, with an average width of 59 m, a depth ranging between 3.5 and 5 m, and gradient of 5.4 cm/km. The longitudinal column of the main canal of the Shatt Al-Basrah canal is 29 km, in addition to the Garmat Ali branch (currently closed) with a length of 6.3 km and the Hammar Marsh branch with a length of 24.5 km [16,17].

The main objective of the Shatt Al-Basrah Canal is to control flood waves that are used to raise the levels of Basrah's rivers, mitigate the impact of sea tides on areas west of Basrah, and reduce their effects on lands adjacent to the canal's path. According to some geological opinions, the course of the Shatt Al-Basra is the course of the ancient Euphrates River [20]. Water samples were collected seasonally from April 2024 to February 2025, with two trips per season, at three designated sampling sites along the Shatt Al-Basrah Canal (Table 1). The first site was located near the regulator, whereas the second site was located near the Mohammed Al-Qasim Bridge, about 9.5 km away from the first site. Finally, the third site is located at the Al-Khawrah Bridge opposite Basrah International Airport, about 22 km away from the first site (Figure 1).

Table 1. Localities of the study sites and their GPS coordinates.

Site	**Location**	
	Latitude (N)	**Latitude (E)**
St.1	30° 24′ 46″	47° 46′ 27″
St.2	30° 29′ 39″	47° 44′ 06″
St.3	30° 35′ 05″	47° 39′ 33″

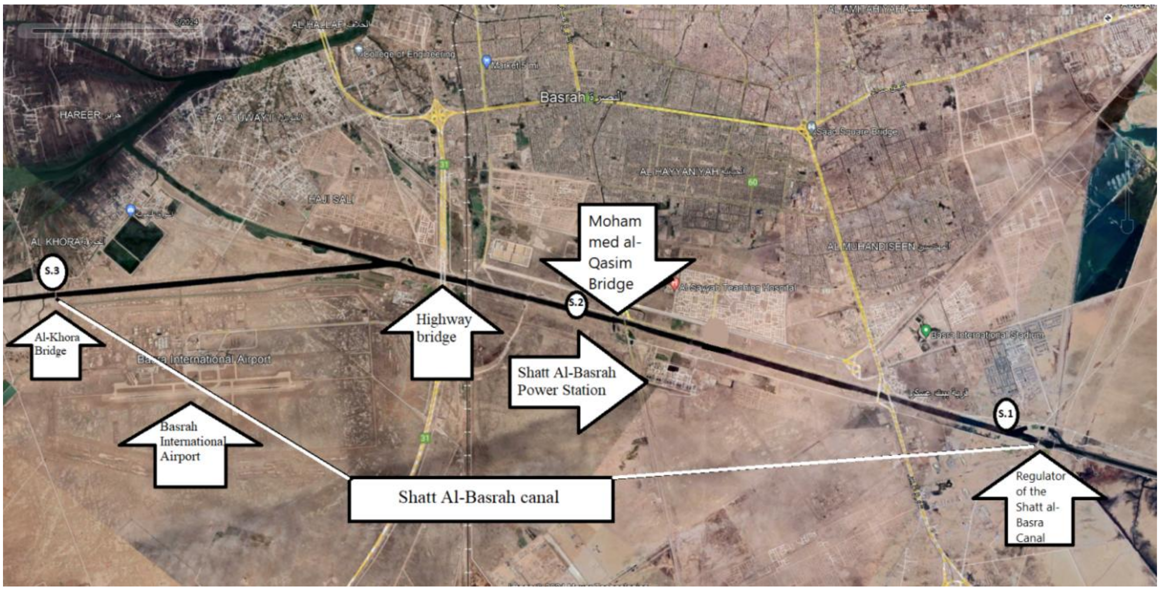

Figure 1. Map showing the location of study sites at Shatt Al-Basrah canal. Environmental Protection Agency (EPA).

2.2. Physical and Chemical Parameters

Several physical, chemical and biological parameters were measured for the application of the indices. The depth of the Secchi disc was measured using a 20 cm diameter disc colored black and white. Dissolved oxygen (DO) was measured according to the American Public Health Association (APHA) [21] method, which was field- and laboratory-tested. For Biological Oxygen Demand (BOD_5), the samples were left unstable in the field and transported, sealed and refrigerated to the laboratory. They were placed in a dark incubator at 20°C for five days. Oxygen was then stabilized in the bottles and its quantity was extracted according to a previously described method. Total suspended solids were calculated using the gravimetric method, as described for APAH [21]. The Chemical Oxygen Demand (COD) concentrations were measured by taking 2 ml of the selected water sample and adding it to a special test kit with a concentration range of 150 $mg.l^{-1}$. The samples were then digested in a digester for two hours and measured using a spectrophotometer.

One liter of water samples from each of the three selected stations was filtered using Gf/C paper, and chlorophyll was extracted using the 90% acetone method. Nutrients were measured in the laboratory by using standard methods. Nitrate and nitrite concentrations were measured according to the APAH [21] method, whereas active phosphates were measured according to the Environmental Protection

Agency (EPA) [22] method. Total nitrogen was determined using a digestion mixture consisting of potassium sulfate, copper sulfate, and sulfuric acid using the Kjeldahl method. The total phosphate content of the samples was estimated using a series of steps. The sample was digested, 50 ml of the sample was taken, nitric acid (5 ml) and sulfuric acid (1 ml) were added, and the sample was placed on a heat source until evaporation occurred. When most of the sample was evaporated, it was removed from the source. Then, 20 ml of distilled water and a few drops of the phenonphthalene indicator were added. Sodium hydroxide was added to increase the pH value. The color turned pink, and the solution was added to 100 ml of distilled water. The ammonia measured by take 20 ml of samples and sodium hydroxide was added to raise the pH value, and the sample was placed in a Kjeldahl test tube, where it was treat with boric acid and titrated with sulfuric acid. Samples were taken from the study area and the necessary analyses were carried out to determine the percentage of ammonium present in the sample. This was done by taking 20 ml of the sample, adding magnesium oxide, transferring it to a Kjeldahl test tube, receiving boric acid and titrating with sulfuric acid [23].

2.3. Trophic Indices

Environmental indicators play a significant role in transforming water quality data, which are often incomprehensible and complex, into information with standardized terms that are interpretable and understandable to non-specialists. These indicators were designed to support periodic environmental monitoring programs and facilitate decision-making by government officials. Among the most commonly used indicators are the trophic status index (TSI), the trophic level index (TLI), the trophic index (TRIX), organic pollution indices (OPI), and the river pollution index (RPI), each of which is specifically designed to focus on specific aspects of water quality.

2.3.1. Trophic State Index (TSI)

The TSI for the Shatt Al-Basrah canal was used. The index relied on three variables: chlorophyll a (Chl-a), total phosphorus (TP), and Secchi disc depth (SD) according to Carlson [24], and was calculated using the following equations:

$$\text{TSI (SD)}=60 - 14.41 \,\text{Ln(Secchi disc depth (m))} \quad (1)$$

$$\text{TSI (Chl-a)}=9.81 \,\text{Ln (Chlorophyll a } (\mu g.l^{-1})) + 30.6 \quad (2)$$

$$\text{TSI (TP)}=14.42 \,\text{Ln (Total phosphorus} (\mu g.l^{-1})) + 4.15 \quad (3)$$

$$\text{Average TSI} = [\text{TSI (TP)} + \text{TSI (Chl-a)} + \text{TSI (SD)}]/3 \quad (4)$$

In contrast, Kratzer and Brezonik [25] added total nitrogen (TN) instead of TP according to the following equations:

$$\text{TSI (TN)} = 54.45 + 14.43 \ln(\text{total nitrogen} (mg.l^{-1})) \quad (5)$$

Table 2. Water Trophic Index Scale [26].

Categories TSI Index	Trophic State
≤40	Oligotrophic
40<CTSI≤50	Mesotrophic
50<CTSI≤70	Eutrophic
CTSI>70	Hypertrophic

2.3.2. Trophic Level Index (TLI)

The index was used in New Zealand, which includes four parameters, Chl-a concentrations, SD depth, total phosphorus (TP) and total nitrogen (TN) [27]. This index was calculated using the following equations [27,28] :

$$\text{TLI(Chl-a)} = 2.22 + 2.54 \log(\text{Chl-a}) \quad (6)$$

$$TLI(SD) = 5.10 + 2.27 \log(1/SD - 1/40) \tag{7}$$

$$TLI(TP) = 0.218 + 2.92 \log(TP) \tag{8}$$

$$TLI(TN) = -3.61 + 3.01 \log(TN) \tag{9}$$

Calculation of TLI is as below

$$TLI = [TLI(Chl\text{-}a) + TLI(SD) + TLI(TP) + TLI(TN)]/4 \tag{10}$$

Table 3. Values of different trophic levels of TLI index [27,28].

TLI values	Trophic State
0.0-1.0	Ultra-microtrophic
1.0-2.0	Microtrophic
2.0-3.0	Oligotrophic
3.0-4.0	Mesotrophic
4.0-5.0	Eutrophic
5.0-6.0	Supertrophic
6.0-7.0	Hypertrophic

2.3.3. Trophic Index (TRIX)

Vollenweider et al. [29] presented a multimetric (complex) trophic index called (TRIX) based on four physiochemical and biological parameters (Chl-a, DO, DIN and DIP). TRIX was used to calculate and contains useful parameters for describing the trophic state of the river system according to the following formula:

$$TRIX\text{ -a} =(\log10 [chl\text{-}a *aD\%O*DIN *DIP]+K) / M \tag{11}$$

or

$$TRIX\text{ -b} =(\log10 [chl\text{-}a *aD\%O*DIN *TP]+K) / M \tag{12}$$

Where:
Chl-a: chlorophyll-a concentration ($\mu g.l^{-1}$),
aD%O: oxygen as the absolute percentage deviation from oxygen saturation (DO, %),
minN: mineral nitrogen, dissolved inorganic nitrogen: DIN: N (as NO_3-N + NO_2-N + NH_4-N) ($\mu g.l^{-1}$),
TP: total phosphorus ($\mu g.l^{-1}$)
The scale coefficients, K= 1.5 and M = 1.2 are, suggested by Giovanardi and Vollenweider (2004) to fix the index scale range between (0 -10).

Table 4. The TRIX index scaled [30-32].

TRIX value	State water quality	Level of eutrophication
0<TRIX≤2	excellent	Ultra-oligotrophic
2<TRIX≤4	high	Low (oligotrophic)
4< TRIX≤5	good	medium (mesotrophic)
5<TRIX≤6	moderate	High (Mesotrophic to eutrophic)
6<TRIX≤10	poor and degraded	Elevated (Eutrophic)

2.3.4. Organic Pollution Indexes (OPI)

The Organic Pollution Index (OPI) described by Leclercq [33] was used to assess the organic content in the Shatt Al-Basrah Canal. The OPI principle is based on dividing index values into five categories (Table 4). This index was obtained from the values of the biological oxygen demand (BOD_5), nitrite, phosphate, and ammonium. The calculation principle is to assign a descriptive or numerical value to each variable according to its concentration in the results of the current study measurements, as shown in Table 5, and then the category number is determined using the average of the data.

Table 5. Evaluation of the level of organic pollution [33].

Classes	NH_4^+ ($mg.l^{-1}$)	NO_2^- ($\mu g.l^{-1}$)	PO_4^{3-} ($\mu g.l^{-1}$)	BOD_5 ($mg.l^{-1}$)	OPI values	Organic pollution level
5	< 0.1	5	15	< 2	4,6 - 5	Null
4	0.1 - 0.9	6 - 10	16 - 75	2 - 5	4 - 4.5	Low
3	0.9 - 2.4	11 - 50	76 - 250	5.1 - 10	3 - 3.9	Moderate
2	2.4 - 6	51 - 150	251 - 900	10.1 - 15	2 - 2.9	Strong
1	> 6	> 150	> 900	> 15	1 - 1.9	Very strong

2.3.5. River Pollution Index (RPI)

The River Pollution Index (RPI) was used to determine the extent of pollution in the Shatt Al-Basrah Canal. This index includes four variables: dissolved oxygen (DO), biochemical oxygen demand (BOD_5), suspended solids (SS) and ammonia nitrogen (NH_3-N) [34]. Each variable was ultimately converted into a four-point sub-index (1, 3, 6, and 10). The overall index was then divided into four pollution levels (unpolluted, slightly polluted, moderately polluted, and highly polluted) by calculating the average of the four sub-indices (Table 6).

$$RPI= 1/ 4 \sum Si \tag{13}$$

i=1

where Si represents the index scores and the RPI value ranges from 1 to 10.

Table 6. Definition of river pollution index (RPI) [34].

Items/ranks	Good-Unpolluted	Slightly polluted	Moderate polluted	Severely polluted
DO ($mg.l^{-1}$)	Above 6.5	4.6–6.5	2.0–4.5	Under 2.0
BOD_5 ($mg.l^{-1}$)	Under 3.0	3.0–4.9	5.0–15	Above 15
TSS ($mg.l^{-1}$)	Under 20	20–49	50–100	Above 100
NH3-N $mg.l^{-1}$)	Under 0.5	0.5–0.99	1.0–3.0	Above 3.0
Index Scores (Si)	1	3	6	10
RPI	Under 2	2.0–3.0	3.1–6.0	Above 6.0

3. Results and Discussion

Some physical, chemical, and biological characteristics of the Shatt Al-Basrah Canal water were studied to determine organic pollution levels and to apply specific indicators to clarify the interrelated variables that affect pollution levels and render the water unfit for conventional uses (Table 7).

Table 7. Ranges of water parameters at Shatt Al-Basrah Canal sites during the studied period**.**

Parameters (Unite)	Site 1 Mean (range)	Site 2 Mean (range)	Site 3 Mean (range)
SD (cm)	64.45 (59-68.5)	58.75 (37.4-75.5)	68.5 (28.5-75.5)
TSS ($mg.l^{-1}$)	58.89 (34.66-66.83)	53.32 (30.62-67.3)	50.465 (35.7-53.89)
Chl.a ($mg.l^{-1}$)	3.05 (2.4-3.8)	3.05 (2.1-3.9)	5.6 (4.9-6.4)
DO ($mg.l^{-1}$)	2.3 (2.1-2.9)	3.2 (2.8-3.6)	4.7 (4.5-5.8)
BOD_5 ($mg.l^{-1}$)	14.7 (12.1-16.4)	14.7 (12.6-18.3)	12.95 (10.9-13.9)
COD ($mg.l^{-1}$)	77.15 (53-83)	73 (49.4-80.03)	44.4 (42.7-47.8)
TN ($mg.l^{-1}$)	33.1 (32.08-44.7)	31.94 (31.3-38.8)	35.55 (34.4-37.9)
TP ($mg.l^{-1}$)	25.4 (22.4-27.2)	26.05 (21.8-32.8)	23 (22.4-25.5)

Parameters (Unite)	Site 1 Mean (range)	Site 2 Mean (range)	Site 3 Mean (range)
NO_2 ($mg.l^{-1}$)	1.505 (1.154-1.91)	1.165 (0.77-1.57)	1.00 (0.81-1.1)
NO_3 ($mg.l^{-1}$)	8.9 (5.44-9.2)	10.1 (6.61-10.4)	12.05 (10.82-16.9)
NH_3 ($mg.l^{-1}$)	2.25 (1.2-2.7)	1.47 (1.35-1.86)	1.5 (0.6-2.1)
NH_4 ($mg.l^{-1}$)	5.45 (4.5-5.7)	4.05 (3-4.5)	2.25 (2.1-4.2)
PO_4 ($mg.l^{-1}$)	3.023 (2.4-3.85)	4.595 (4.2-5.99)	5.85 (4.9-7.2)

Compared with the results of previous studies, most of the results of environmental factors in current study of the Shatt Al-Basrah Canal are higher than those previously recorded for the canal [1,4,10,13-19].

Water quality assessments in water bodies are essential tools for evaluating the environmental status and suitability of water systems for various purposes. These assessments are typically based on the measurement of basic environmental parameters (physical, chemical, and biological), each of which addresses a fundamental aspect of water safety. Important physical parameters include water temperature, turbidity, conductivity, and total suspended solids. Chemical parameters include pH, DO, BOD_5, chemical oxygen demand (COD), in addition to nutrient levels (nitrate, nitrite, ammonium, and phosphate), as well as the presence of heavy metals (such as lead, mercury, cadmium, and arsenic). Biological measurements depend on multiple organisms and the quality of the water body (fresh, brackish, salty), such as the quality and quantity of microorganisms, plant and animal plankton, large invertebrates, and bacterial indicators such as coliforms and E. coli, which provide long-term reflections of water quality fluctuations and exposure to pollution [35].

Naturally, abstract and complex numbers can be difficult for non-experts to understand. Therefore, it is necessary to facilitate this process by transforming abstract numerical data into simple numbers associated with understandable and easy-to-interpret terms. This was achieved by using environmental indicators. The most common indicators are the Water Quality Index (WQI), Tropical Index (TRIX), and Organic Pollution Index (OPI). These indicators provide easy-to-understand terms and phrases for water quality, such as "excellent," "good," "poor," or "unusable," enabling comparative assessments across different regions and time periods. For example, the Canadian Council of Ministers of the Environment Water Quality Index (CCME-WQI) is a globally recognized and popular model that considers the range, frequency, and extent of deviations from established guidelines [36]. Likewise, the TRIX index can be frequently used to assess nutrient conditions and eutrophication in different aquatic environments, whereas the OPI focuses specifically on organic pollutants and their potential to cause eutrophication and oxygen depletion. These indicator-based tools support informed decision-making, enhance environmental transparency, and are increasingly being used in both national monitoring programs and international water quality frameworks [37].

The concentrations of water quality parameters have been used to calculate several indices including TSI, TLI, TRIX, OPI, and RPI. The results for these indices are listed in Table 8.

Table 8. The values of nutritional and pollution indicators at study sites.

Sites	TSI		TLI		TRIX		OPI		RPI	
	Values	Descrip.	Values	Descrip.	values	Descrip.	Values	Descrip.	values	Descrip.
1	93.95	hypertrophic	7.68	hypertrophic	6.33	Bad Eutrophic	1.5	Very Strong polluted	7	Severely polluted
2	94.09	hypertrophic	7.703	hypertrophic	6.46	Bad Eutrophic	2	Strong polluted	7	Severely polluted
3	96.03	hypertrophic	7.81	hypertrophic	6.92	Bad Eutrophic	2	Strong polluted	4.5	Moderately polluted

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The nutritional (trophic) indices calculations, TSI and TLI, classified the three sites in the current study as high nutrient levels (hypertrophic). This seems logical and reflects the high nutrient concentrations. Meanwhile, the TRIX values indicated that the three sites had poor water quality and high nutrient levels (Bad Eutrophic). Despite some differences in the components of the indicators TSI, TRIX and TLI, they all agreed on the presence of high nutrient levels in the water at the sites studied. This seems logical for both sites one and two, as they receive large quantities of untreated sewage. The third site, which is far from these pollutants, but it was receives agricultural sewage with high nutrient concentrations [16,18].

The Trophic State Index (TSI) serves as a diagnostic tool for evaluating the nutrient status and productivity of water bodies. Originally developed for lakes and reservoirs, it has also been adapted for rivers and canals to detect signs of eutrophication, a process driven by nutrient over-enrichment that leads to excessive algal blooms and oxygen depletion. The TSI is typically based on three factors chlorophyll-a (biological parameter), total phosphorus (chemical parameter), and Secchi depth (physical parameter), this is beneficial for forecasting the ecological consequences of nutrient loading over time [37].

However, Zhang et al. [38] recommended that not using SD and TP if water depth is less than 2 m, and excluding TN from eutrophication assessments if water depth is greater than 5 m. More broadly, other factors such as zooplankton grazing may have a significant influence on the empirical relationships between TN (or TP), Chl.a, and SD with water depth. On the other hand, the TSI index relies on the Secchi disc by more than 60%, while its influence by total phosphorus and chlorophyll was reduced by 20%. Other factors have also been shown to affect eutrophication variables, such as suspended solids (SS) and turbidity. The study concluded that the TSI index has limited applicability for determining trophic status in the presence of persistent turbidity not due to algal growth, compared with Chl-a, which is a distinct indicator of algal growth [39].

In this study, total nitrogen and total phosphorus were used to calculate the index due to their importance in primary productivity and, consequently, their relationship with chlorophyll, a component of the index [40]. Zhang et al. [38] noted that in lakes and rivers, chlorophyll-a has been observed to respond to changes in total nitrogen or total phosphate concentrations. Similarly, the TRIX index can be commonly used to assess trophic conditions and eutrophication in different aquatic environments, prevalence of mesotrophic to eutrophic conditions was the results of TRIX index that obtain in the Parnaíba River Delta, northeast Brazil. using of TRIX index approach is as benefit tool for evaluation of both water quality and trophic status in tropical estuaries [41].

The OPI results showed that the water at site 1 was classified as highly polluted, whereas the water at Sites 2 and 3 was highly polluted. The organic pollution index results did not show significant differences between the study stations. This may be due to the similarity of the canal water mass owing to its low flow velocity and the absence of any clear or tangible change in its mass. This could lead to the accumulation of nutrients and pollutants in the water along the Shatt Al-Basrah Canal, especially in light of the falling water levels in the Iraq rivers, in addition to the sharp decline in rainfall in the Iraqi alluvial plain in recent years. Furthermore, the regulator works to prevent the intrusion of tidal water from the Gulf, as its entry would help dilute the pollutants in the canal.

As is well known, the OPI focuses specifically on indicators of organic pollution, which often come from domestic wastewater, biomass decomposition, and industrial waste. In general, this index is based on the key parameters: BOD_5, ammonia, nitrite, and phosphate, each of which reflects the biological oxygen demand (BOD_5) and nutrient enrichment associated with the decomposition of organic matter. High OPI values indicate environments prone to oxygen depletion and over-eutrophication, often leading to habitat degradation and biodiversity loss [42].

The OPI is particularly useful for local assessments of the impact of organic waste and is of particular value in areas where domestic and agricultural runoff is prevalent. On the other hand, this indicator was used to assess the status of industrial organic pollution of Klou River in Central Benin. The results for pollution ranged from medium to strong, depending on the sources of pollution and the direction of the river. The study concluded that the water is unfit for human use, in addition to the river water posing a threat to biodiversity [43]. Chemical Pollution Load was assessment in the water of Turkestan

Region, Five of Eight stations were detected as polluted stations owing to presence of high levels of Al and Fe were natural erosion and industrial waste are the source of their [44].
Finally, the RPI classified Sites 1 and 2 as highly polluted, whereas Site 3 was moderately polluted. The results of the RPI index are similar to those of the previous indices, with the difference that Site 3 is moderately polluted. This is likely due to the nature and weight of the environmental components included in the index (DO, BOD_5, TSS, and NH_3) all of which yielded similar results to Site 3, which was far from direct sewage pollution but was in direct contact with agricultural pollutants from the third river.
Bhuyan et al. [45] applied the RPI on Old Brahmaputra River and their results shows fluctuates from low to high pollution. As well as, they found there are a strong positive linear relationships between several parameters include Alkalinity vs. Chloride, COD vs. BOD , Chloride vs. EC, Alkalinity vs. EC , and Hardness vs. EC. This fact related to their communal origin from industrial seepages, municipal wastes, as well as agricultural activities.
According to Al-Mahmoud and Al-Bahli [16] the water of the Shatt Al-Basrah Canal falls into the highly degraded category of the Canadian WQI model.
Untreated household wastewater is discharged from residential areas in Basrah, ending up in this canal. A significant increase in the amount of was been observed owing to the continuous increase in the annual population. As a result of this pollution, the quality of river water has changed significantly from its natural state, becoming laden with massive amounts of organic matter that are harmful to the environment and threaten public health [14].
Several studies have concluded that most water quality variables are higher than permissible levels compared with international and regional standards for residential and agricultural use without treatment. They are also higher than the standards for Syrian and Jordanian drainage water. A comparison of water quality at the three study stations showed that most pollutants are present at high concentrations and are harmful to the environment [14,15,16,18], in addition, the danger of deterioration of the water condition of the Shatt Al-Basrah River is the industrial waste discharged from the Basrah oil refinery and the Shatt Al-Basrah gas power station [1].
Collectively, these indices not only simplify environmental datasets but also provide a framework for consistent assessment, trend analysis, and interregional comparisons. When used in combination, as in the current study, they offer a multidimensional perspective on river health and pollution sources, thereby enhancing the scientific basis for water resource management and environmental protection.
Although a substantial body of research has emerged over the past two decades addressing water quality in southern Iraq, much of it remains fragmented and generalized, with few studies offering a focused or methodologically integrated examination of the Shatt Al-Basrah Canal as a distinct hydrological system. Many existing studies concentrate on the broader Shatt Al-Arab River system, thereby overshadowing the unique environmental and socio-economic dynamics of the Shatt Al-Basrah, which is subject to more localized forms of pollution stemming from urban, industrial, and agricultural activities specific to the Basrah region.

Conclusions

The results of the current study revealed that the quality of water in the Shatt Al-Basrah Canal significantly deteriorated. Despite the use of several indices that included various environmental variables, all indices indicated that the Shatt Al-Basrah canal water had high nutrient concentrations and is highly polluted, especially at the point of collection at the canal regulator. The results of the two nutrient indices, TSI and TLI, indicated that the water was hypertrophic, whereas TREX indicated that the water was very rich in nutrients and therefore of poor quality. The OPI and RPI indices indicated that the water from the stations was moderately to highly polluted, especially near the regulator. The results of our current study are a cause for alarm, especially for specialists and government agencies responsible for water resources and the environment, due to the rapid and significant deterioration in the quality of the Shatt al-Basra waterway and the danger this poses to the population as well as to the living organisms living in and around it. It is imperative that the relevant authorities expedite the development of serious plans to treat the canal water and restore the environmental quality of the canal water.

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