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# Assessing Sirwan River Water Quality based on a single-factor assessment and comprehensive pollution index methods

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## Abstract

In this paper, single-factor assessment methods and comprehensive pollution index were chosen to evaluate the Sirwan River water quality situation. The mean physicochemical values of dissolved oxygen, total dissolved solids, turbidity, color, major cations, and anions ranged from 7.77 ± 0.55 to 7.80 ± 0.18 mg $L^{-1}$; 472.83 ± 23.97 to 478.83 ± 24.23 mg $L^{-1}$; 8.13 ± 8.28 to 14.61 ± 15.76 NTU; 14.15 ± 5.76 to 25.07 ± 17.19 Hazen; Calcium from 62.19 ± 2.05 to 64.06 ± 1.72 mg $L^{-1}$; Magnesium 21.20 ± 2.01 to 21.74 ± 1.47 mg $L^{-1}$; Sodium 17.68 ± 2.79 to 22.44 ± 2.76 mg $L^{-1}$; Potassium 2.50 ± 0.22 to 2.64 ± 0.18 mg $L^{-1}$; Bicarbonate 284.76 ± 5.43 to 289.80 ± 5.87 mg $L^{-1}$; Chloride 18.10 ± 6.71 to 18.69 ± 7.82 mg $L^{-1}$; Sulfate 59.70 ± 3.23 to 67.67 ± 3.01 mg $L^{-1}$; and Nitrate 3.06 ± 02.90 to 3.85 ± 1.34 mg $L^{-1}$, during the study, respectively. Using the single-factor assessment approach, it was determined that the concentration of total dissolved solids was observed at (S5), turbidity and color at (S4, S5, and S6), and bicarbonate exceeded the standard at all sites. During the study, the comprehensive water pollution index rates changed from 0.49 to 0.87 with a mean of 0.62 ± 0.16 and from 0.44 to 1.12 with a mean of 0.74 ± 0.30. According to the estimation results of both methods there was a slight to moderately polluted water class at all sites of the studied river.

Key words: Water quality assessment, water pollution, physicochemical analysis, Sirwan River.

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## Introduction

Water is a pressing compound for all living things on Earth. [1] State that freshwater from lakes, rivers, and streams are a scarce reference that is primary for a person's life. Nevertheless, universal water quality has been rebuffing swiftly over the years through the influence of both natural and human-caused factors, as outlined in [2]. Research on water quality is a serious and elusive matter. The Sirwan River is a lifeline for nearly a million Iraqi Kurds. Internal, public, agricultural, and other usages are seriously dependent on the Sirwan River in cities along the river. Water quality assessment for several water uses, such as internal use, irrigation, industrial uses, fish culture, animal watering, drinking, domestic uses, maintenance, and manufacturing use, is a significant plan for food care and social wellbeing. [3] Showed that water quality valuation objects to categorizing the origins of water effluence and to progressing a plan for maintainable water source management, the protection and rise of social conditions, and further common and economic evolution. According to [4] study, the best way to organize water quality is to use the pollution index assessment (PIA) method. The PIA is a calculation technique built on the physic-chemical valuables of the monitoring documents and applies the index evaluation method. In the study conducted by [5], they found that the sub-indices derived from categorizing observation documents based on calculation indicator can serve as a standard for assessing water quality. In the research by [6], it was demonstrated that the PIA can be distributed into two components: a single-factor evolution index (SFEI) and a comprehensive pollution index (CPI) method built on the amount of assessment plans selected from the observing facts. According to [7] study, the SFEI method is a recent pollution assessment technique utilized in various research projects, particularly for evaluating water pollution. Employing SFPI analysis can enable the identification of the primary pollutant in a specific location. However, since pollutants are additional possible to have immediate environmental effects, the SFEI method alone may not be sufficient to address the combined environmental effects of pollutants [8]. The CPI can express frequent parts of water quality data, but overlooks the change in rank of particular water quality signs when estimating [9]. In the past, various researchers, like [10], utilized the (CPI). [11] employed both (CPI) and (SFEI) to assess the quality of river water. [12] Also applied (SFEI and CPI) to examine water effluence and the key issues within the river's watershed. Additionally, (SFEI and CPI), and additional indices was applied by [13] to study water class and classify the primary contaminants in the river. Therefore, the purposes of this work were twofold: (1) to evaluate the effluence levels at water sample sites using (SFEI and CPI), and (2) to identify the primary sources and pollutants that impact river water condition, ultimately influencing the safe and sustainable usage of resources.

## Materials and Methods

### Study area and sample collection

The study area covers latitudes (34° 36' 55.97" to 35° 7' 7.66") North, and longitudes (45° 20' 4.42" to 45° 43' 13.25") East from Darbandikhan Dam to Kalar district. Since the study area is characterized by population density along the riverbank in addition to the presence of certain industrial and agriculture activities, these sites are of great importance for drinking water. There are also a lot of sewers overflowing on both sides of the river. To achieve the study objectives (dry and rainy seasons), from six different sites samples were collected Figure (1) within the dam and its downstream section along the Sirwan River over two seasons. Because water quality can change over time due to a variety of factors including temperature, sunlight exposure, biological activity, and chemical reactions, the sampling was done on the same day. The criteria used to select the sampling site were based on land use trends in the area. Samples were collected during the rainy season in April 2022, and dry season in August 2022. To avoid unexpected changes in properties, samples were collected in plastic bottles that had been acid-washed, from a depth ranging between 10 and 15 centimeters below the water surface, following the usual procedure [14].

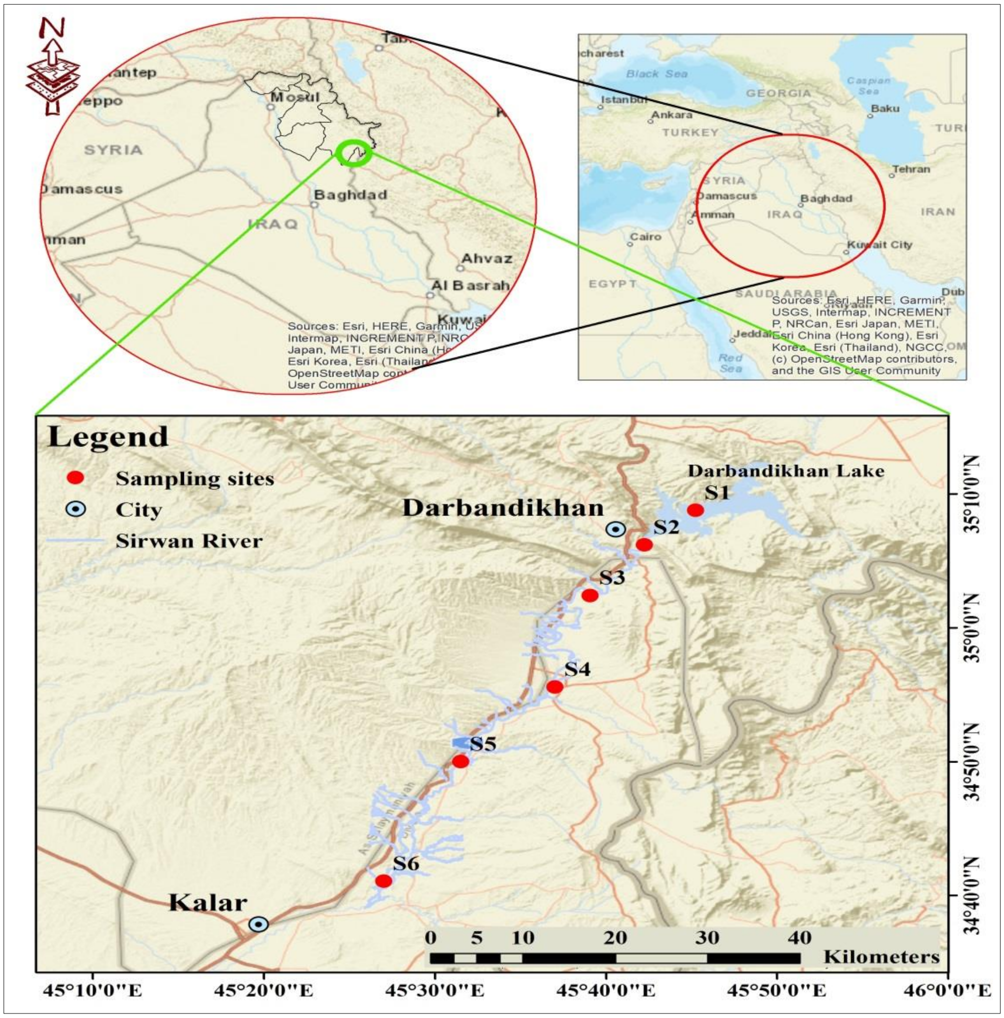

Figure 1: Map for sampling sites.

On-site measurements were taken for temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), and total dissolved solids (TDS) during sampling. The values for temperature, DO, pH, EC, and TDS were computed utilizing specialized equipment: an oxygen-sensitive membrane electrode (InoLab.OXi730, WTW Company-Germany), for DO, a pH meter (Multi 340i/SET Multiparameter-Instrument WTW Company-Germany), for pH, and an EC/TDS-meter (Cond 330i, 82362 Weilheim WTW Company-Germany), for EC and TDS. Turbidity was carried out by using a turbidity meter (Photo Flex/Photo Flex Turb.WTW Company-Germany). Main cations and anions were identified through titrimetric methods, while color was assessed using PhotoLab spectral, following the procedures outlined in [15] and [16], respectively.

## Pollution Index Assessment Method

### Single-factor evolution index and comprehensive pollution index

The use of the (SFEI) is intended to estimate the impact of specific parameters that affect water quality on water effluence. On the other hand, the (CPI) is used to estimate the total formal water effluent and arrange the quality of surface water. For this, the measured limits of water quality and the permissible limitation of the amount of surface water quality limits according to environmental standards are required. An allowable standard limit specified in drinking water quality guidelines [17] was utilized for the computation of SFEI and CPI. In accordance with the methods outlined in [18], the single rating factor and overall pollution index are calculated using the mathematical expressions provided in Eqs. 1 and 2, by using 15 water quality parameters.

$$\mathbf{SFEI} = \boldsymbol{Mi/Si} \qquad (1)$$

SFEI refers to an evaluation index assigned to individual water quality parameters, where *Mi* (mg $L^{-1}$) denotes the detected amount of each limit, and *Si* (mg $L^{-1}$) embodies the maximum allowable standards for surface water corresponding to that parameter. According to the findings of [19], the interpretation of the outcome is as monitors: if the value of the SFEI is below 1, the water quality conforms to the surface water quality guidelines. Conversely, if the SFEI rate exceeds 1, it signifies that the quality of water overdoes the established values, indicating pollution of the water [12].

$$\mathbf{CPI} = \frac{\mathbf{1}}{\boldsymbol{n}}\sum_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{n}} \boldsymbol{Mi/Si} \qquad (2)$$

In this context, the CPI stands for a comprehensive index used to assess water impurity. The term *Mi* stands for the recorded property of individual parameters, while *Si* represents the set conjectural quality value for surface water. The variable '*n*' signifies the whole count of limits. According to [20], water class arrangement perhaps divided within five different groups based on an assessment of the calculated CPI value, as explained in Table (1).

Table (1) Values of the CPI and their corresponding groupings and explanations for river water quality [20].

| CPI values | Water quality grouping | An explanation of the water quality condition |
|---|---|---|
| 0-0.2 | I | Clean |
| 0.21-0.4 | II | Sub clean |
| 0.41-1 | III | Slightly polluted |
| 1.01-2 | IV | Medium polluted |
| ≥ 2.01 | V | Heavily polluted |

## Results and discussion

Table (2) displays the expressive statistics of the initial data pertaining to the fifteen water quality limits of the Sirwan River.

According to [21], temperature is a compelling physical constraint on water quality, affecting the quantity of dissolved oxygen in water and physicochemical actions. Table (2) shows the average and standard deviation of water sample temperatures exhibited variations ranging from 17.18 ± 2.63 to 20.67 ± 5.62 $^{o}$C. The highest temperature was measured at (S1) upstream. Conversely, the lowest temperature was measured at (S2) both during the dry season. According to [22], there are minor temperature fluctuations downstream, possibly attributed to changes in elevation, leading to increased sunlight exposure and varying levels of water contamination. Dissolved oxygen is an imperative indicator of water quality. The mean levels of DO differ from 7.77 ± 0.55 to 7.80 ± 0.18 mg $L^{-1}$. The highest DO concentration was measured at (S1) and the lowest at (S4) together during the rainy season. High DO concentrations are due to low organic contributions from nearby cropland, limited turbidity and suspended particles, and the photosynthetic activity of green plants [23], while low DO content at (S4) is primarily due to high organic pollution from both human activities and natural sources, which has led to a reduction in the amount of DO in the water. In accordance with [24], pH serves as a physical constraint on water quality, similar to temperature, and can potentially impact biochemical responses, metabolic processes, the poisonousness of metals to marine organisms, and the fitness of water for a range of purposes. In the current investigation, the mean pH ideals ranged from 7.64 ± 0.20 to 7.87 ± 0.29. The uppermost pH reading was registered at (S5), whereas the lowermost was observed at (S2), during the rainy season, both events take place. A slightly alkaline nature of the river water may result from the release of raw manufacturing wastewater toward the river, which may contain cleaners and soaps and due to chemical composition of catchment area or geological formation of the area [25], whereas the lowest pH is associated with a relatively minor level of human-made influence. Surface water quality can be impacted by EC and TDS. [26] Elevated levels of TDS can considerably influence the sensitivity and tastiness of water, while increased salinity can impair water's fitness for agricultural irrigation. The mean values of EC and TDS of water samples varied from 404.67 ± 41.54 to 419.50 ± 49.09 µs $cm^{-1}$ and 472.83 ± 23.97 to 478.83 ± 24.23 mg $L^{-1}$, respectively Table (2). The EC and TDS values reached their highest value at (S5) in the dry season, respectively, whereas the lowest values were found at (S2) and (S4) respectively and both in the rainy season. The highest loads of EC and TDS can result from the input of liquefied and postponed solids toward the river system against human actions. According to [27], the water's turbidity is a significant factor that impacts the permeation of light into the seabed and thus aquatic life. Increased turbidity decreases the amount of daylight that reaches the underlying phytoplankton in aquatic systems. This is achieved by dispersing and impeding incoming light through the presence of suspended materials, including mud, algae, detritus, feces, clay, and small organic particles. In the course of this investigation, the findings for turbidity and color ranged 8.13 ± 8.28 to 14.61 ± 15.76 NTU and 14.15 ± 5.76 to 25.07 ± 17.19 Hazen, respectively. In (S4), the highest turbidity and color were each achieved in the dry period. The most elevated concentrations might arise from the release of domestic refuse, sewage, and sediment-laden irrigation channels. Allowing to [18], water turbidity could be influenced by clay and silt with fine mineral and animate particles in addition to the presence of algae and microbes. While the lowest turbidity and color values in (S2) were recorded during the dry and rainy seasons, respectively. The presence of an excessive concentration of positive and negative ions can impact the quality of surface water through various mechanisms. As indicated in Table (2), the mean Calcium concentrations varied between 62.19 ± 2.05 to 64.06 ± 1.72 mg $L^{-1}$, the Magnesium concentrations from 21.20 ± 2.01 to 21.74 ± 1.47 mg $L^{-1}$, and Sodium concentrations between 17.68 ± 2.79 to 22.44 ± 2.76 mg $L^{-1}$, Potassium varied between 2.50 ± 0.22 to 2.64 ± 0.18 mg $L^{-1}$, Bicarbonate ranged from 284.76 ± 5.43 to 289.80 ± 5.87 mg $L^{-1}$, Chloride ranged from 18.10 ± 6.71 to 18.69 ± 7.82 mg $L^{-1}$, Sulfate ranging from 59.70 ± 3.23 to 67.67 ± 3.01 mg $L^{-1}$, and Nitrate from 3.06 ± 02.90 to 3.85 ± 1.34 mg $L^{-1}$.

Table (2) Values of the studied water parameters and their mean ±SD.

| Variables | Seasons | S1 | S2 | S3 | S4 | S5 | S6 | Mean ± SD |
|---|---|---|---|---|---|---|---|---|
| Temperature C$^{o}$ | Rainy | 15.2 | 14.5 | 15.5 | 17.1 | 20.4 | 20.4 | 17.18 ± 2.63 |
| | Dry | 29.9 | 14.2 | 16.8 | 17.9 | 22.1 | 23.1 | 20.67 ± 5.62 |
| DO mg L$^{-1}$ | Rainy | 8.75 | 7.69 | 7.71 | 7.11 | 7.90 | 7.43 | 7.77 ± 0.55 |
| | Dry | 8.11 | 7.79 | 7.81 | 7.68 | 7.83 | 7.56 | 7.80 ± 0.18 |
| pH | Rainy | 7.31 | 7.79 | 7.91 | 8.06 | 8.08 | 8.04 | 7.87 ± 0.29 |
| | Dry | 7.64 | 7.28 | 7.72 | 7.60 | 7.79 | 7.83 | 7.64 ± 0.20 |
| EC µs cm$^{-1}$ | Rainy | 406 | 360 | 374 | 380 | 464 | 444 | 404.67 ± 41.51 |
| | Dry | 411 | 363 | 391 | 394 | 490 | 468 | 419.50 ± 49.09 |
| TDS mg L$^{-1}$ | Rainy | 456 | 460 | 462 | 455 | 514 | 490 | 472.83 ± 23.97 |
| | Dry | 463 | 462 | 470 | 462 | 521 | 495 | 478.83 ± 24.23 |
| Turbidity NTU | Rainy | 2.80 | 1.30 | 1.41 | 8.39 | 12.50 | 22.40 | 8.13 ± 8.28 |
| | Dry | 1.50 | < 0.01 | 1.64 | 34.90 | 18.90 | 30.70 | 14.61 ± 15.76 |
| Color Hazen units | Rainy | 10.7 | 8.5 | 8.9 | 16.8 | 16.9 | 23.1 | 14.15 ± 5.76 |
| | Dry | 11.1 | 8.8 | 12.2 | 50.1 | 28.5 | 39.7 | 25.07 ± 17.19 |
| Calcium mg L$^{-1}$ | Rainy | 66.33 | 64.20 | 65.20 | 62.60 | 64.40 | 61.60 | 64.06 ± 1.72 |
| | Dry | 61.52 | 60.80 | 61.20 | 60.40 | 65.80 | 63.40 | 62.19 ±2.05 |
| Magnesium mg L$^{-1}$ | Rainy | 19.34 | 20.04 | 19.32 | 21.24 | 23.64 | 23.64 | 21.20 ± 2.01 |
| | Dry | 20.14 | 21.72 | 22.56 | 22.80 | 19.80 | 23.40 | 21.74 ± 1.47 |
| Sodium mg L$^{-1}$ | Rainy | 22.78 | 24.10 | 20.24 | 18.32 | 26.03 | 23.14 | 22.44 ± 2.76 |
| | Dry | 15.38 | 15.89 | 16.82 | 15.89 | 22.43 | 19.64 | 17.68 ± 2.79 |
| Potassium mg L$^{-1}$ | Rainy | 2.08 | 2.52 | 2.62 | 2.72 | 2.52 | 2.52 | 2.50 ± 0.22 |
| | Dry | 2.32 | 2.69 | 2.59 | 2.69 | 2.69 | 2.88 | 2.64 ± 0.18 |
| Bicarbonates mg L$^{-1}$ | Rainy | 299.21 | 292.19 | 290.36 | 286.09 | 289.14 | 281.82 | 289.80 ± 5.87 |
| | Dry | 293.34 | 287.31 | 285.48 | 284.26 | 278.16 | 279.99 | 284.76 ± 5.43 |
| Chlorides mg L$^{-1}$ | Rainy | 15.23 | 17.04 | 13.49 | 10.30 | 26.63 | 25.92 | 18.10 ± 6.71 |
| | Dry | 10.56 | 11.72 | 15.98 | 17.40 | 27.69 | 28.76 | 18.69 ± 7.82 |
| Sulfates mg L$^{-1}$ | Rainy | 72.12 | 66.04 | 65.04 | 66.48 | 70.80 | 65.52 | 67.67 ± 3.01 |
| | Dry | 64.21 | 57.36 | 57.84 | 56.40 | 59.28 | 63.12 | 59.70 ± 3.23 |
| Nitrate mg L$^{-1}$ | Rainy | 3.20 | 1.51 | 4.04 | 3.34 | 2.62 | 3.66 | 3.06 ± 0.90 |
| | Dry | 5.12 | 1.62 | 5.01 | 4.54 | 3.06 | 3.74 | 3.85 ± 1.34 |

To realize the whole grade of water effluence in the Sirwan River and to find the key limitations responsible to pollution, both a SFEI and CPI were practiced [19]. Assessing water quality is typically an actual compound method involving different types of pollutants found in river water. Globally employed for evaluating water quality, the CPI is a moderately potent valuation tool that offers complete insights into the condition quality of water [11]. Giving to [12], both SFEI and CPI are methodologies applicable for investigating primary water impurities and appraising the degree of water effluence. In this research, Table (3) displayed the outcomes of the SFEI and the CPI.

Table (3) Results of water quality assessment for Sirwan River by using SFEI and CPI.

| Variables | Seasons | SFEI | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | S1 | S2 | S3 | S4 | S5 | S6 | Mean ± SD |
| Temperature | Rainy | 0.61 | 0.58 | 0.62 | 0.68 | 0.82 | 0.82 | 0.69 ± 0.11 |
| | Dry | 1.20 | 0.57 | 0.67 | 0.72 | 0.88 | 0.92 | 0.83 ± 0.22 |
| DO | Rainy | 0.25 | 0.48 | 0.46 | 0.55 | 0.28 | 0.40 | 0.40 ± 0.12 |
| | Dry | 0.21 | 0.47 | 0.40 | 0.40 | 0.24 | 0.28 | 0.34 ± 0.10 |
| pH | Rainy | 0.21 | 0.53 | 0.61 | 0.71 | 0.72 | 0.69 | 0.58 ± 0.20 |
| | Dry | 0.43 | 0.19 | 0.48 | 0.40 | 0.53 | 0.55 | 0.43 ± 0.13 |
| EC | Rainy | 0.27 | 0.24 | 0.25 | 0.25 | 0.31 | 0.30 | 0.27 ± 0.03 |
| | Dry | 0.27 | 0.24 | 0.26 | 0.26 | 0.33 | 0.31 | 0.28 ± 0.03 |
| TDS | Rainy | 0.91 | 0.92 | 0.92 | 0.91 | 1.03 | 0.98 | 0.95 ± 0.05 |
| | Dry | 0.93 | 0.92 | 0.94 | 0.92 | 1.04 | 0.99 | 0.96 ± 0.05 |
| Turbidity | Rainy | 0.56 | 0.26 | 0.28 | 1.68 | 2.50 | 4.48 | 1.63 ± 1.66 |
| | Dry | 0.30 | 0.00 | 0.33 | 6.98 | 3.78 | 6.14 | 3.15 ± 2.92 |
| Color | Rainy | 0.71 | 0.57 | 0.59 | 1.12 | 1.13 | 1.54 | 0.94 ± 0.38 |
| | Dry | 0.74 | 0.59 | 0.81 | 3.34 | 1.90 | 2.65 | 1.67 ± 1.15 |
| Calcium | Rainy | 0.88 | 0.86 | 0.87 | 0.83 | 0.86 | 0.82 | 0.85 ± 0.02 |
| | Dry | 0.82 | 0.81 | 0.82 | 0.81 | 0.88 | 0.85 | 0.83 ± 0.03 |
| Magnesium | Rainy | 0.64 | 0.67 | 0.64 | 0.71 | 0.79 | 0.79 | 0.71 ± 0.07 |
| | Dry | 0.67 | 0.72 | 0.75 | 0.76 | 0.66 | 0.78 | 0.72 ± 0.05 |
| Sodium | Rainy | 0.11 | 0.12 | 0.10 | 0.09 | 0.13 | 0.12 | 0.11 ± 0.01 |
| | Dry | 0.08 | 0.08 | 0.08 | 0.08 | 0.11 | 0.10 | 0.09 ± 0.01 |
| Potassium | Rainy | 0.17 | 0.21 | 0.22 | 0.23 | 0.21 | 0.21 | 0.21 ± 0.02 |
| | Dry | 0.19 | 0.22 | 0.22 | 0.22 | 0.22 | 0.24 | 0.22 ± 0.02 |
| Bicarbonates | Rainy | 1.50 | 1.46 | 1.45 | 1.43 | 1.45 | 1.41 | 1.45 ± 0.03 |
| | Dry | 1.47 | 1.44 | 1.43 | 1.42 | 1.39 | 1.40 | 1.42 ± 0.03 |
| Chlorides | Rainy | 0.06 | 0.07 | 0.05 | 0.04 | 0.11 | 0.10 | 0.07 ± 0.03 |
| | Dry | 0.04 | 0.05 | 0.06 | 0.07 | 0.11 | 0.12 | 0.07 ± 0.03 |
| Sulfates | Rainy | 0.36 | 0.33 | 0.33 | 0.33 | 0.35 | 0.33 | 0.34 ± 0.02 |
| | Dry | 0.32 | 0.29 | 0.29 | 0.28 | 0.30 | 0.32 | 0.30 ± 0.02 |
| Nitrate | Rainy | 0.07 | 0.03 | 0.09 | 0.07 | 0.06 | 0.08 | 0.07 ± 0.02 |
| | Dry | 0.11 | 0.04 | 0.11 | 0.10 | 0.07 | 0.08 | 0.09 ± 0.03 |
| CPI | Rainy | 0.49 | 0.49 | 0.50 | 0.64 | 0.72 | 0.87 | 0.62 ± 0.16 |
| | Dry | 0.52 | 0.44 | 0.51 | 1.12 | 0.83 | 1.05 | 0.74 ± 0.30 |

As shown in Figures (2 and 3), during the period studied the value of the (SFEI) for temperature at (S1), TDS at (S5), turbidity at (S4, S5 and S6) was measured. At sites (S4, S5, and S6), the color levels, as well as bicarbonate levels at all sampling sites, exceeded a value of one (SFEI > 1). This indicates that the recorded values significantly exceed the established surface water quality ideals, implying that the river water at these specific sites is contaminated. [19] Attribute this contamination to human-induced causes of organic substance and nutrients, as well as natural sources. Nonetheless, SFEI values are below one (<1) for certain assessed variables such as DO, pH, EC, and prominent ions (both cations and anions except bicarbonate). This means that the recorded measurements are below established surface water quality standards, meaning that these factors have played no role in water pollution, as noted by [12].

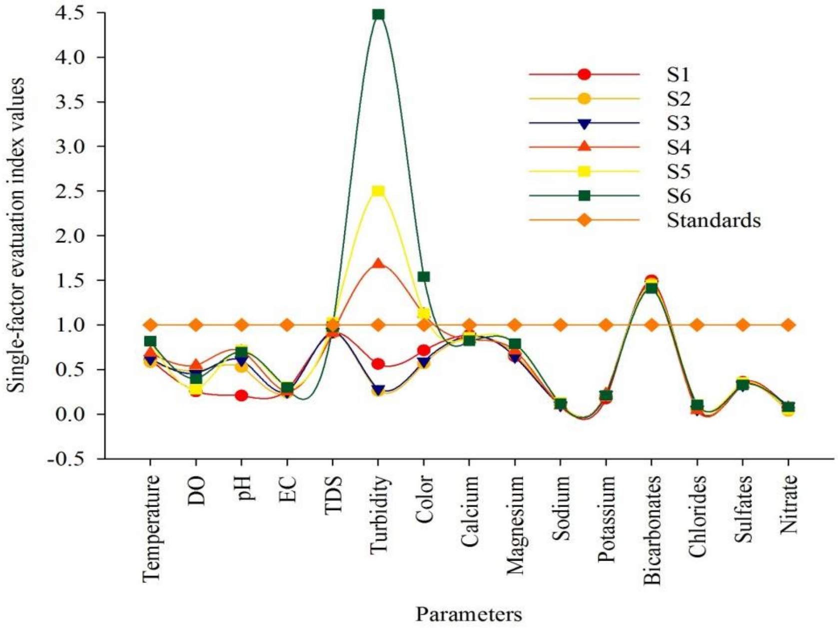

Figure 2: SFEI fluctuations of water quality limitations during the rainy season.

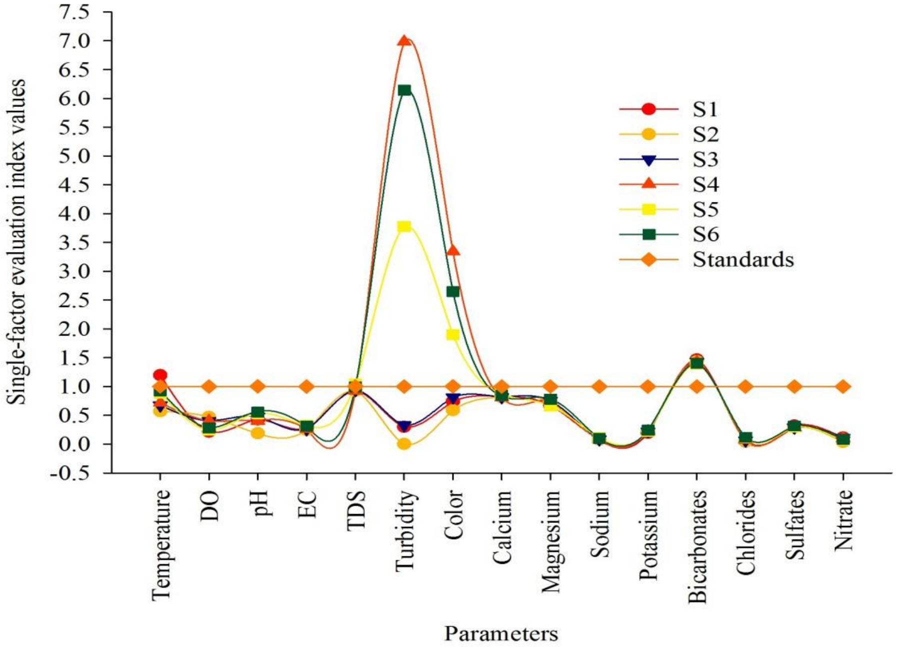

Figure 3: SFEI fluctuations of water quality limitations during the dry season.

In the rainy season, the CPI varied within the range of 0.49 to 0.87, averaging at 0.62 ± 0.16. Conversely, during the dry season, the CPI fluctuated from 0.44 to 1.12, with a mean value of 0.74 ± 0.30. CPI amounts diverse between sites, suggesting that all sites studied had dissimilar ranks of effluence. But, during the dry season, the maximum CPI was noted at (S4) as shown in Table (3) and Figure (4); this suggests that overall water pollution was worst at (S4). Physicochemical analyzes of river water samples showed that (S4) had the highest loads of turbidity, color and bicarbonate in irrigated vegetables by reason of high loads of animate matter, nutrients, livestock manure, household waste, sewage, septic tanks and agrochemicals. Thus, this site had the maximum CPI in comparison to the other sampling sites. Figure (4) exhibited upward trends, reaching their peak at (S4). Afterward, progressively declining trends sideways the river could be owing to declining pollutant load and the effects of the river's self-cleansing downstream. The CPI during the rainy season increased along the studied sites and reached a maximum at (S6) due to increasing pollution levels along the river. Agreeing to [20], the CPI ideals achieved indicated that the river water falls within the classification categories III (0.41–1) to IV (1.01–2) at all the sampled sites, centered on the water class arrangement. Consequently, the water quality of river is categorized as having a slightly to moderately polluted. These findings demonstrate a moderate decline in the class of the river water across all sampling sites.

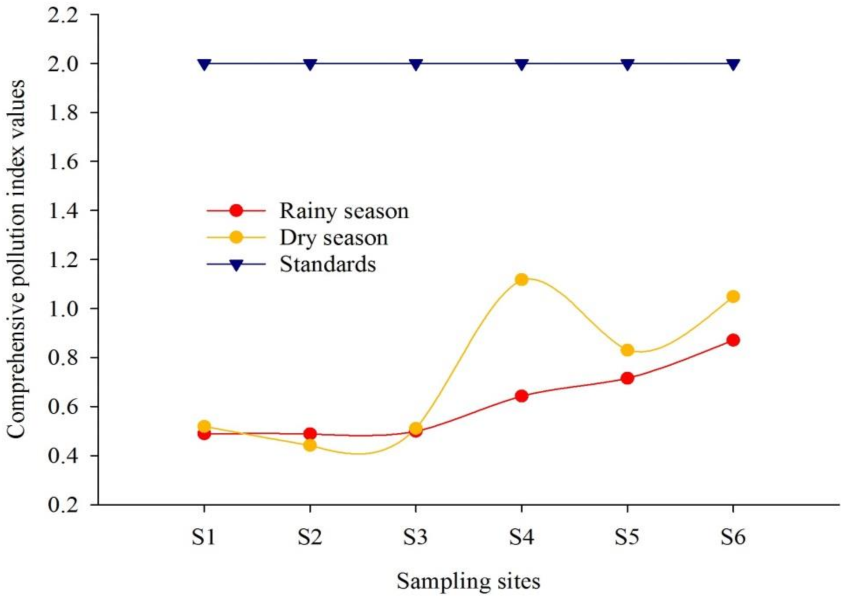

Figure 4: Variations of CPI along sampling sites throughout the study duration.

## Conclusion

The study found that levels of physic-chemical parameters such as TDS, turbidity, color and bicarbonate exceeded drinking water quality guidelines recommended by the WHO. This result shows that river water quality at some sites was mainly affected by anthropogenic pollution sources such as industrialized, residential, urban, sewage, and agricultural chemical inputs. The valuation outcomes of the one-factor index identifying water quality displayed that the key pollutants in the Siwan River consisted mainly of bicarbonate, followed by turbidity, color and low TDS. The CPI showed water pollution in the river at the sampling site (S4 and S6). Hence, the findings from this investigation demonstrate that water quality in the lower section of the main river channel declined overall because of the gradual buildup of pollutants along the course of the flow. The index approaches for finding water quality can effectively classify sites through the utmost severe effluence conditions to arrange water quality controlling and remediation actions.

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مجلة جامعة كركوك للعلوم الزراعية

# تقييم جودة مياه نهر سيروان باستخدام تقييم أحادي العامل وطرق مؤشر التلوث الشامل

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## الملخص

في هذا البحث، تم اختيار طرق التقييم أحادية العامل ومؤشر التلوث الشامل لتقييم حالة جودة مياه نهر سيروان. تراوحت معدلات القيم الفيزيائية والكيميائية المعيارية للأكسجين المذاب، والمواد الصلبة الذائبة الكلية، والعكارة، واللون، والكاتيونات الرئيسية، والأنيونات من 7.77 ± 0.55 إلى 7.80 ± 0.18 ملغم/لتر، 472.83 ± 23.97 إلى 478.83 ± 24.23 ملغم/لتر، 8.13 ± 8.28 إلى 14.61 ± 15.76 NTU، 14.15 ± 5.76 إلى 25.07 ± 17.19 هازن، الكالسيوم من 62.19 ± 2.05 إلى 64.06 ± 1.72 ملغم/لتر، المغنيسيوم 21.20 ± 2.01 إلى 21.74 ± 1.47 ملغم/لتر، الصوديوم 17.68 ± 2.79 إلى 22.44 ± 2.76 ملغم/لتر، البوتاسيوم 2.50 ± 0.22 إلى 2.64 ± 0.18 ملغم/لتر، بيكربونات 284.76 ± 5.43 إلى 289.80 ± 5.87 ملغم/لتر، كلوريد 18.10 ± 6.71 إلى 18.69 ± 7.82 ملغم/لتر، كبريتات 59.70 ± 3.23 إلى 67.67 ± 3.01 ملغم/لتر، والنترات 3.06 ± 02.90 إلى 3.85 ± 1.34 ملغم/لتر، أثناء الدراسة، على التوالي. باستخدام التقييم أحادي العامل، كما أن تركيز المواد الصلبة الذائبة الكلية لوحظ عند (S5)، والعكارة واللون عند (S4، S5، S6)، وتجاوز البيكربونات المعيار في جميع المواقع. وخلال الدراسة تغيرت معدلات المؤشر الشامل لتلوث المياه من 0.49 إلى 0.87 بمتوسط 0.62 ± 0.16 ومن 0.44 إلى 1.12 بمتوسط 0.74 ± 0.30. وفقا لنتائج التقدير لكلا الطريقتين، كانت هناك فئة مياه ملوثة بشكل طفيف إلى معتدل في جميع مواقع النهر المدروسة.

**الكلمات المفتاحية:** تقييم جودة المياه، تلوث المياه، التحليل الفيزيائي الكيميائي، المصادر البشرية، نهر سيروان.