Evaluating Surface Water Quality of Euphrates River in Al-Najaf Al-Ashraf, Iraq with Water Quality Index (WQI)

Suhair Razzaq Al Sharifi
Civil Engineering Department, College of Engineering, University of Kufa, Najaf, Iraq
suhairr.alsharifi@uokufa.edu.iq

Hanadi H. Zwain
Structure and Water Resources Engineering Department, College of Engineering, University of Kufa, Najaf, Iraq
hanadi.alzuwayyin@uokufa.edu.iq

Zinah K. Hasan
Civil Engineering Department, College of Engineering, University of Kufa, Najaf, Iraq
zinahk.albdairi@uokufa.edu.iq (corresponding author)

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ABSTRACT

The present study illustrates the rapid pollution of Euphrates River, inwards Al-Najaf Al-Ashraf governance (Al-Kufa River) in Iraq, which is one of the most important rivers in the region. The river faces formidable pressure due to encroachments, discharge of untreated domestic and industrial waste, drainage water from cultivated orchards, and dumping of solid waste. This study was conducted to assess the temporary and locative organic pollution in the region. Water Quality Index (WQI) of the Al-Kufa river was determined according to the Canadian Council of Ministers of Environment (CCME) method by calculating seven parameters (water temperature, DO, COD, EC, TDS, turbidity, and pH) in two sampling stations. Surface water samples were collected in a period of four months (September to December) in 2023. WQI level, correlation analysis between parameters, and Iraqi and CCME drinking water specification standards were employed to classify the surface water status. The results show that the ecological condition can be classified as marginal with WQI= 49 and poor with WQI= 42 in stations 1 and 2, respectively.

Keywords-CCME; Chemical Oxygen Demand (COD); Al-Kufa river; Water Quality Index (WQI)

I. INTRODUCTION

The rivers have always been important water resources and the preponderance development activities are constancy dependent upon them. Rivers assimilate industrial and municipal wastewater, compost discharges, and runoff, all accountable for the water river pollution [1]. The degree of contamination is generally assessed by studying the physical and chemical advantages of the water framework [2-3]. A monitoring program should include certain parameters, such as Chemical Oxygen Demand (COD) [4, 5].

Researchers generally define pollution as an unendurable change in the chemical, physical, and biological attributes of air, soil, and water that has harmful effects on human life, and animals, and plants [6-8]. Many previous studies have used environment hazard estimations as tools for water management because it potential ecological hazards can be can predicted from different pollutants [1, 2]. Iraqi river waters are affected from the discharges of industrial, agricultural, and household wastewaters [9, 10]. Nonpoint source pollution is not easy to be controlled, and it is one of the most significant environmental problems [4]. This study was carried out on Euphrates River (Al-Kufa river), which is a fundamental source of water in Al-Najaf Al-Ashraf province to assess its water quality.

II. OBJECTIVES AND IMPORTANCE OF THIS RESEARCH

In environmental chemistry, COD is indicative to the amount of oxygen that can be consumed by chemical reactions. Also, it is a measure of the concentration of organic materials that can be oxidized chemically without the intervention of microorganisms [9]. Thus, this study aims to estimate COD as an indicator of the organic pollution. In addition, assessment and categorization of the surface water quality of the river was conducted according to CCME, by measuring seven parameters which were used to calculate the Water quality index (WQI) at two locations over a period of four months.

III. RESEARCH METHODOLOGY

A. Study Area

The study area is located on the brims of the Al-Kufa River in Al-Najaf Al-Ashraf Governorate, with the sampling stations been located at 44°.39'23"036 E longitude and 32°.04'90"997 N latitude and 44°.44'49"695 E longitude and 31°.98'94"774 N. The Euphrates River branches before entering the Al-Najaf Al-Ashraf Governorate to the Al-Abbasiyah River and the Al-Kufa River [1]. This city depends entirely on the Al-Kufa River and its branches to meet its drinking water requirements and to irrigate its agricultural lands (Figure 1). Furthermore, on the riverbanks, sewage water is drained into the river directly, along with mostly untreated wastewater from the wastewater treatment plant [1, 5], affecting the river environment.

(a)

(b)

Fig. 1. The study area (a) GIS, (b) Google maps, © Google.

B. Data Collection

Water samples were collected every two weeks, at two stations, the first (S1) was distant from the pollution and the second (S2) was adjacent to the entry of the sewage of the treatment plant (Figure 2).

Fig. 2. Untreated wastewater before it is disposal into the river.

WQI was assessed during the period from September to December of 2023 by measuring seven physical and chemical parameters. The analyzed parameters included water temperature (Tw), hydrogen ion concentration (pH), Dissolved Oxygen (DO), Total Dissolved Solids (TDS), turbidity, Electrical Conductivity (EC), and COD.

IV. CCME WATER QUALITY INDEX FORMULATION

The CCME WQI index was developed to be used as a tool for the definition of the water quality [10-13]. The index consists of three factors:

F1 (Scope) constitutes the extent of water quality criterion's non-compliance. It has been embraced explicitly from the British Columbia Index:

$$F1 = \frac{\text{Number of failed variables}}{\text{Total aggregate number of variables}} \times 100$$

F2 (Frequency) exhibits the percentage of isolated tests that do not encounter objectives (failed tests):

$$F2 = \frac{\text{Number of failed tests}}{\text{Total aggregate number of tests}} \times 100$$

F3 (Amplitude) exhibits the magnitude the failed individual test values do not meet their objectives. F3 is recapitulated in three proceedings.

In this juncture, the number of times by which a solitary concentration is out of the specified limits, either above, or below them, it is depicted as an excursion and is, respectively, expressed as:

$$\text{Excursion}_i = \frac{\text{Objective}_i}{\text{Failed test value}_i} - 1$$

$$\text{Excursion}_i = \frac{\text{Objective}_i}{\text{Failed test value}_i} + 1$$

The collective amount by which isolated tests are out of compliance is considered by aggregating the excursions of isolated tests of their objectives and dividing by the aggregate number of tests. This variable, indicated to as the Normalized Sum of Excursions (nse), is calculated by:

$$\text{nse} = \frac{\sum_{i=1}^{n} \text{excursion}_i}{\text{Number of tests}}$$

F3 is calculated by:

$$F3=\frac{nse}{0.01nse+0.01}$$

Finally, the WQI is calculated by:

$$WQI_{CCME}=100-((\sqrt[2]{F_1^2+F_2^2+F_3^2})/1.732)$$

The results of the WQI of the surface water in this study are compared with the allowable limits of Iraqi drinking water specifications standard and CCME water quality standards in Table I. Table II shows the water quality categories according to CCME's WQI.

TABLE I. IRAQI AND CCME WATER QUALITY STANDARDS

Parameter	River maintenance	Drinking water	Aquatic life	Irrigation
Temperature °C	_	_	**15	_
pH	*6.5-8.5	*6.5-8.5	**6.5-9	*6.5-8.4
TDS (mg/l)	_	*1000	**500	_
EC (µs/cm)	*1000		_	*2250
DO (mg/l)	> 5	_	**5.5-9	
Turbidity (NTU)	_	*5	**5	_
COD	-	-	-	-

* Iraqi drinking water specifications, ** CCME

TABLE II. CCWQI WATER QUALITY CATEGORIES

Grade	WQI	Ecological Condition
A Excellent	95-100	Virtual absence of threat or impairment. Conditions very close to natural or pristine levels. These index values can only be obtained if all measurements are within the objectives virtually all of the time.
B Good:	80-94	Only a minor degree of threat or impairment. Conditions rarely depart from natural or desirable levels.
C Fair:	65-79	Water quality is occasionally threatened or impaired. Conditions sometimes depart from natural or desirable levels.
D Marginal:	45-64	Water quality is frequently threatened or impaired. Conditions often depart from natural or desirable levels.
F Poor	0-44	Water quality is almost always threatened or impaired. Conditions usually depart from natural or desirable levels.

V. METHODOLOGY

The steps of implementing the study plan are illustrated in Figure 3.

VI. RESULTS AND DISCUSSION

The water quality of the Al-Kufa river has been deteriorated for a long time. Hence, the present research was adopted for evaluating the WQI of the Al-Kufa river owing to expresses the expanse of the safety of the environmental in an area exposed to human activity. The WQI of the Euphrates river in Al-Najaf city (Al-Kufa river) was determined according to CCME's methodology by the consideration and measurement of seven parameters (Tw, COD, Turbidity, Ec, DO, TDS, and pH) in two locations over a period of four months.

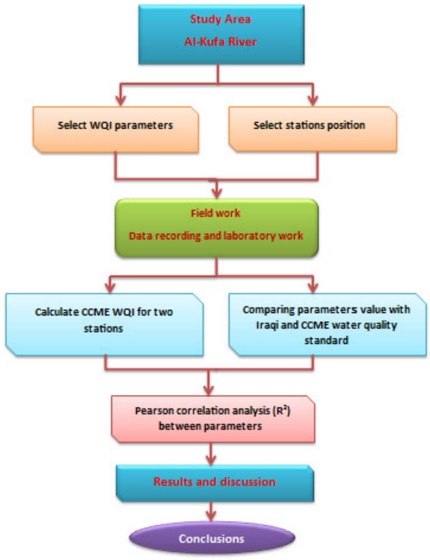

Fig. 3. Methodology of the study.

The results demonstrate that S1 had a WQI equal to 49, thus its ecological condition can be classified as marginal, and its water quality is frequently threatened or impaired. S2 had a WQI value of 42, so its ecological condition can be classified as poor 0-44. The results showed that DO concentration was more correlated with Tw, while COD and TDS had a high correlation with pH. Moreover, COD with DO and TDS with EC were positively correlated. The results of this study bring beneficial notifications regarding the need of improving the water quality in the study area throughout the assessment of environmental friendly measures. Figures 4-10 show the measurement results and Figures 11-15 show the Linear Multiple Regression (LMR) and correlation results,

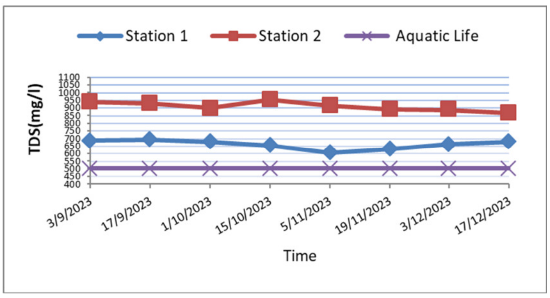

Fig. 4. TDS values in the two stations during the study period.

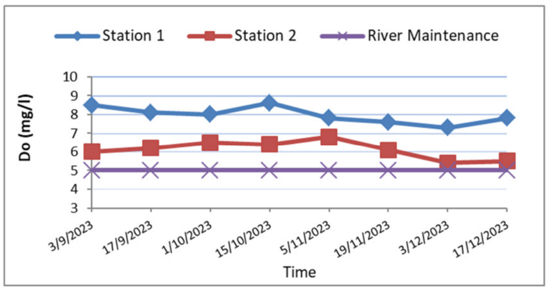

Fig. 5. DO values in the two stations during the study period.

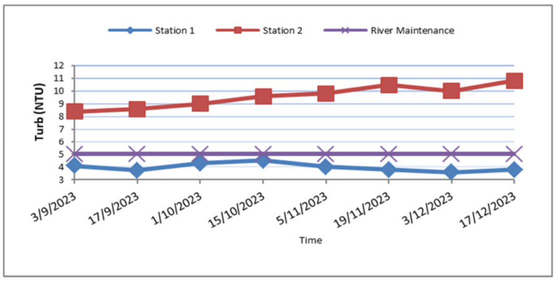

Fig. 6. Turbidity values in the two stations during the study period.

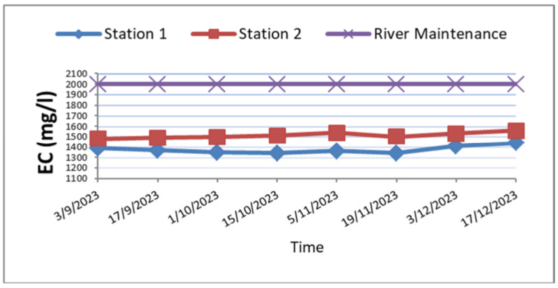

Fig. 7. EC values in the two stations during the study period.

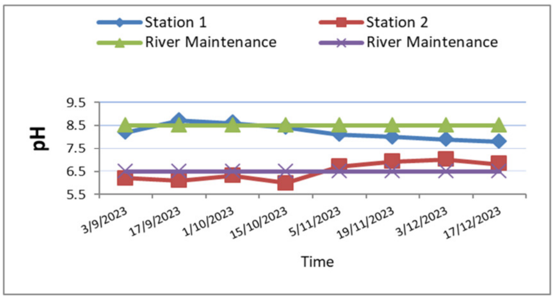

Fig. 8. pH values in the two stations during the study period.

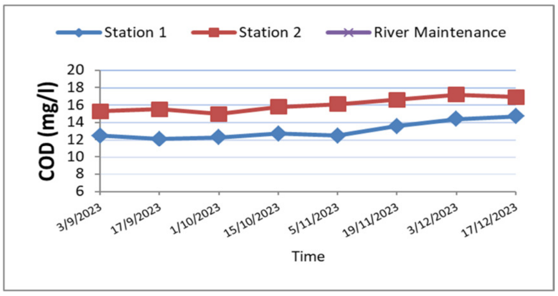

Fig. 9. COD values in the two stations during the study period.

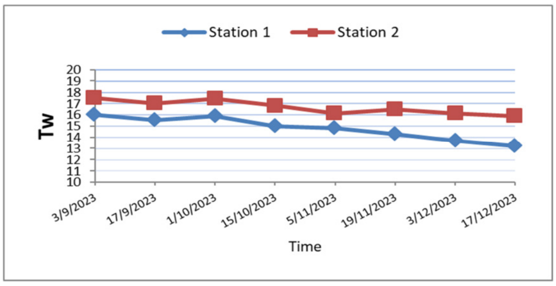

Fig. 10. Water temperature values in the two stations during the study period.

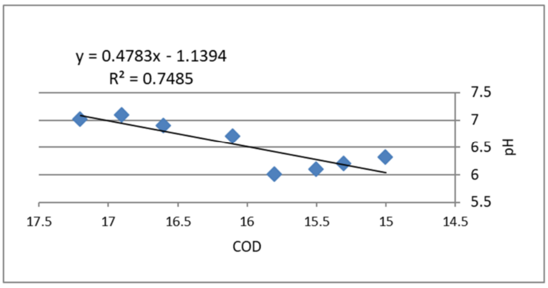

Fig. 11. LMR and correlation of COD data with pH data.

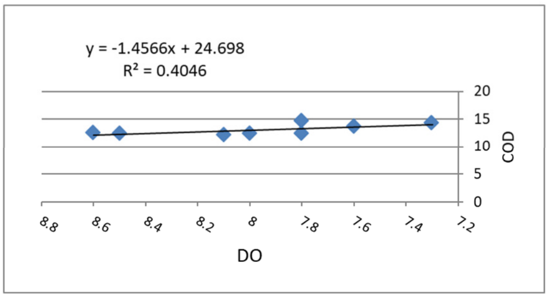

Fig. 12. LMR and correlation of COD data with DO data.

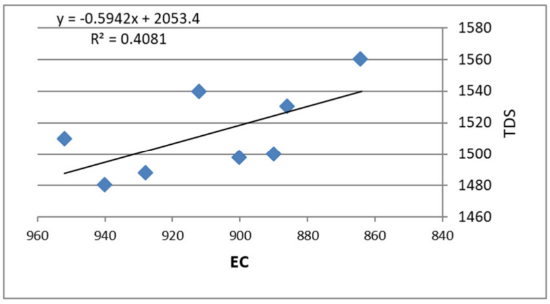

Fig. 13. LMR and correlation of EC data with TDS data.

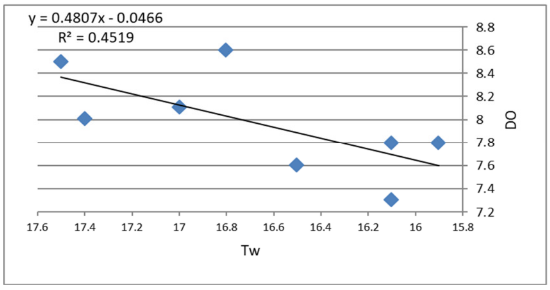

Fig. 14. LMR and correlation of Tw data with DO data.

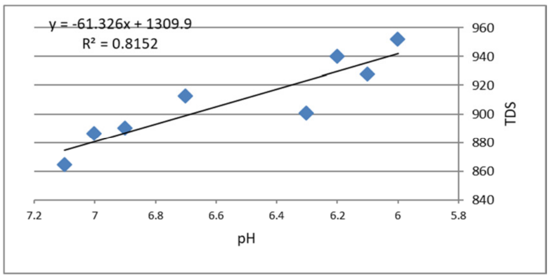

Fig. 15. LMR and correlation of TDS data with pH data.

TABLE III. MAXIMUM, MINIMUM, MEAN, SUM, AND STANDARD DEVIATION OF WATER PARAMETERS FOR TWO STATIONS

Parameter	Stations	Sum	Mean	SD	Max	Min
DO	S1	63.7	7.96	0.44	8.6	7.3
	S2	48.9	6.11	0.48	6.8	5.4
TDS	S1	5275	659.38	29.96	690	604
	S2	7272	909.00	29.70	952	864
EC	S1	11000	1375.00	35.86	1440	1340
	S2	12106	1513.25	27.63	1560	1480
TURB	S1	31.85	3.98	0.30	4.5	3.6
	S2	76.7	9.59	0.87	10.8	8.4
Tw	S1	118.4	14.80	1.01	16	13.2
	S2	133.3	16.66	0.61	17.5	15.9
pH	S1	66.3	8.29	0.38	8.9	7.7
	S2	52.3	6.54	0.44	7.1	6
COD	S1	104.8	13.10	1.00	14.7	12.1
	S2	128.4	16.05	0.79	17.2	15

VII. CONCLUSION

After the completion of the field work, laboratory tests, and the processes needed to analyze the results, the following conclusions were reached:

1. The current study showed a rise in most physical and chemical values, which confirms the negative impact of wastewater and agricultural wastewater discharging on the river. Furthermore, the pH values could encourage organic pollution in the second region.
2. These values are caused by the direct discharge of sewage in the river. Station 2 was more polluted than station 1, due to the discharge of sewage from the wastewater treatment plant which has a negative impact on the quality of water, resulting from the inefficient removal of contaminants.
3. The water bodies in Iraq are exposed to pollution as a result of the excesses of wastewater discharge from various sources.
4. The climate factor plays a role in water pollution of Al-Kufa river, especially temperature and evaporation.
5. The agricultural activities of the adjacent land of the river contributed to the pollution of the river throughout the discharge of irrigation water which contains salts, especially agricultural fertilizers, that are discharged into the river.

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