ASSESSMENT OF THE WATER QUALITY INDEX OF EUPHRATES RIVER BETWEEN HEET AND RAMADI CITIES , IRAQ

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Abstract

The Water Quality Index (WQI) of Euphrates river between Heet and Ramadi cities was carried out using various water quality parameter from November 2008 to June 2009 . Twelve water quality parameters namely Ph , Dissolved Oxygen (DO) , Biochemical Oxygen Demand (BOD) , Turbidity , Total Dissolved Salts (TDS) , Total Suspended Solids (TSS) , Bicarbonate (HCO_3^-) , Sulfate ($SO_4^=$) , Phosphate ($PO_4^=$) , Total Nitrogen (TN) , Chloride (Cl^-) and Fecal Coliform (FC) were considered to compute Water Quality Index (WQI) based on the Canadian council of Ministers of the Environment Water Quality Index methodology (CCME WQI) .

We found that the water quality of Euphrates river in the study area is mostly rated as 〃 marginal 〃 (CCME WQI is 45.17) for over all drinking aquatic uses in the study period . Generally , the water quality was〃 marginal 〃 at the upstream and 〃 poor〃 at the downstream throughout the study period . The deterioration of water quality in Euphrates river can be attributed to natural and anthropogenic sources .

Keywords : Euphrates river , WQI , Water Quality , Physico – chemical parameters

I. Introduction

In order to assess the , suitability of water for diverse uses , there is a need to devolve an index similar to the air quality model that will categorize the quality of water . This index should integrate the significant physico – chemical and biological constituents of water and present them in a simple , yet scientifically defensible manner [1] . The concept of Water Quality Index (WQI) was first proposed by Horton [2] . The most popular WQI was developed in 1970 by the American Public Health Association [3] . In Canada , the Water Quality Index (WQI) was introduced in mid – 90's by Water Quality Guidelines Task Group of the Canadian Council of Ministers of the Environment [4],[5]. This Task Group modified the Original British Columbia Water Quality Index into the CCME Water Quality Index (WQI) , which was endorsed by the CCME [6]. A Water Quality Index (WQI) is defined as a rating reflecting the composite influence of different water quality parameters on the overall quality of water [7] . WQI is an arithmetic tool used to transform large quantities of water quality data into a single cumulatively derived number . It represent a certain level of water quality while eliminating the subjective assessments of such quality [8],[9]. WQI is very useful to transmit information concerning water quality to the public in general , giving a good idea of the evolution tendency of water quality to evolve over a period of time , besides allowing the comparison between different water courses or different locations along the same course [10] . The index is used to determine the general health state of the water body of concern . The index can be used to assess water quality relative to its desirable state (as defined by water quality objectives) and to provide insight into the degree to which water quality is affected by human activity [11] .

The specific variables , objectives and time period used in the index are not specified and indeed , could vary from region to region , depending on local condition and issues . It is recommended that at a minimum , four variables sampled at least four times be used in the calculation of index values [6] .

Water Quality Index (WQI) method has been applied in many countries to assess the overall status of their water bodies , such as United Status [12] ; UK [13]; Canada [14],[15],[1]; India [16],[17],[18];

Brazil [10]; Bangladesh [19]; Kenya ([20] ; [11] . In Iraq , there are two studies about application of WQI method to assess the health state of Euphrates river [21] and Tigris river [22] . The present study is aimed to calculate the Water Quality Index (WQI) of the Euphrates river in order to assess the suitability of its water for human uses .

II. Material and Methods

Study area

The study area is located in Al- anbar governorate between latitude (33º 24ˉ - 33º 39ˉ N) and longitude (42º 47ˉ - 43º 16ˉ E) (Fig. 1) . The area is characterized by arid to semiarid climate with dry hot summer and cold winter ; The area includes the larger urban center in the Al- anbar governorate (Ramadi and Heet) .

Data for WQI Calculation

The data used in this study were provided by Al- Othman ([21] and cover the period from November 2008 to June 2009 . Eleven sampling station were established along the Euphrates river in the study area in order to give a comprehensive idea of aver all quality of the river . The sampling stations descriptions are shown in (Fig . 2) . The water quality of Euphrates river was monitored for a period of eight months by taking the sample once in every month . Water samples were collected from depth of 30 cm beneath the river surface . The water samples were analyzed for 12 physico – chemical and bacteriological parameters (The parameters pH, TDS, and Dissolved Oxygen (DO) were determined at the sampling station and other parameters like Turbidity , Chloride , Total Suspended Solids (TSS) Biological Oxygen Demand (BOD) , Bicarbonate , Total Nitrogen , , Sulfate , Phosphate and Fecal Coliform were analyzed in the laboratory using the standard procedures of APHA [23] .

WQI Calculation

For the calculation of Water Quality Index (WQI) of Euphrates river ,We employed the CCMEWQI . The CCMEWQI comprises of three factors and is well documented [6] , [24] .

F_1 (**scope**) represents the percentage of variables that do not meet their objective at least once during the time period under consideration (″ failed variables ″) , relative to the total number of variables measured :

$$F_1 = \left(\frac{\text{Number of failed variables}}{\text{Total number of variables}}\right) \times 100 \qquad (1)$$

F_2 (**frequency**) represents the percentage of individual tests that do not meet objectives (″ failed tests) :

$$F_2 = \left(\frac{\textbf{Number of failed tests}}{\textbf{Total number of tests}}\right) \times 100 \qquad (2)$$

F_3 (**Amplitude**) represents the amount by which failed test values do not meet their objectives . F_3 is calculated in three steps :

i) The number of times by which an individual concentration is greater than (or less than , when the objective is a minimum) the objective is termed an ″ excursion ″ and is expressed as follows . When the test value must not exceed the objective :

$$excursion_i = \left(\frac{\text{Failed Test Value}_i}{\text{Objectivej}}\right) - 1 \qquad (3a)$$

For the cases in which the test value must not fall below the objective :

$$excursion_i = \left(\frac{\text{objective}_j}{\text{Failed Test Value}_i}\right) - 1 \qquad (3b)$$

If the objective equals zero :

$$\boldsymbol{excursion_i} = \text{Failed Test} \qquad (3c)$$

ii) The collective amount by which individual tests are out of compliance is calculated by summing the excursions of individual tests from their objectives and dividing by the total number of test (both those meeting objectives and those not meeting objectives) . This variable , referred to as the normalized sum of excursions , or *nse* , is calculated as :

$$nse = \frac{\sum_{i=1}^{n} excursion_i}{\# \text{ of tests}} \quad (4)$$

iii) $\boldsymbol{F_3}$ is them calculated by an asymptotic function that scales the normalized sum of the excursions from objectives (*nse*) to yield a range between 0 and 100 .

$$F_3 = \left(\frac{nse}{0.01nse+0.01}\right) \quad (5)$$

Once the factor have been obtained , the index itself can be calculated by summing the three factors as if they were vectors . The sum of the squares of each factor is therefore equal to the square of the index .

The CCME Water Quality Index (CCMEWQI) :

$$CCMEWQI = 100 - \left(\frac{\sqrt{F_1^2+F_2^2+F_3^2}}{1.732}\right) \quad (6)$$

The divisor 1.732 normalizes the resultant values to a range between 0 and 100 , where 0 represents the ″ worst ″ water quality and 100 represents ″ best ″ water quality .

Twelve variable will be considered in the index calculation (dissolved oxygen DO) , PH , Biological Demand Oxygen (BOD) , Turbidity , Total Suspended Solids (TSS) ,Total Dissolve Salts (TDS) , Total Nitrogen (TN) , Phosphate ($PO_4^{=}$) , Sulfate ($SO_4^{=}$), Bicarbonate (HCO_3^-) , Chloride (Cl^-) and Fecal Coliform (FC) . The WQI has been calculated by using the WHO , EPA , Canadian and Iraqi standards (objectives) of drinking water quality (Table 1) .

Once the CCMEWQI has been determined , water quality is ranked by relating it to one of the categories listed in Table 1 [6] .

III. Results and Discussion

Appling the former equations on the results of water analysis data of Euphrates river in the study area (Table 2) showed that the WQI equals to 45.17. This WQI level indicates that water quality in the Euphrates river between Heet and Ramadi cities was Marginal water quality is frequently threatened or impaired ; condition often depart from natural or desirable levels . This low level of WQI of Euphrates river can be attributed to number of variables and test that exceed or less than the objectives . Nine variables and forty four test exceed or less than the objectives . Turbidity , TDS , Sulfate and Fecal Coliform exceed the objective along the period of study .

Nevertheless of number and type of the variables used in calculation of WQI of the Euphrates river the water quality of it continues marginal (Table 3) .

Al – Othman [21] calculated the WQI of Euphrates river for the same area and the period using method of the National Sanitation Foundation (NSFWQI) . She found that the WQI level is (68) and the water quality is rated as medium . This water quality status (medium) meets the water quality status (marginal) in the CCMEWQI [6]. To study sensitivity of the WQI, we investigated the temporal and spatial variation of the WQI. The results showed ″ poor″ water quality in April and ″ Marginal ″ water quality in other months (Fig. 3) . The ″ poor ″ quality in April can be attributed to the measured TDS that exceeded largely the objective and its excursion was large and reflects the intervention between effects of natural and those of anthropogenic activities . The results of spatial variation analysis of WQI showed ″ poor ″ to ″ marginal ″ quality in all stations (Fig. 4) . Generally , the water Quality was ″ marginal ″ at the upstream and ″ poor″ at the downstream throughout the study period . This might be due to increasing pollution of river water from urban wastes and anthropogenic activities in Ramadi city located at the downstream . The WQI level in the station 7 was higher than other stations . This station locates distant from the urban wastewater sources .

IV. Conclusions

The Water Quality of the Euphrates river between Heet and Ramadi cities is mostly rated as ″ marginal ″ (CCMEWQI is 45.17) for overall drinking and aquatic uses in the period between November 2008 and June 2009 .The ″marginal″ water quality is frequently threatened or impaired ; condition often depart from natural or desirable levels . This quality is impacted by nine Physico-Chemical and bacteriological parameters (BOD, Cl^-, FC, HCO_3^-, $PO_4^{=}$, TDS, TN , TSS, Turbidity and

$SO_4^{=}$) exceed the standards (objective) of drinking water . This can be attributed to natural and anthropogenic sources . The temporal variation of WQI showed ″ poor″ water quality in April and ″ marginal ″ water quality in the other months . The ″ poor″ quality can be attributed to the measured TDS that exceeded largely the objective and its excursion was large . The high level of TDS in April can be attributed to decrease of the river water level to below the water table, which in turn led to the flow of the ground water rich in soluble salts toward the river. Generally , the quality was ″ marginal″ at the upstream and ″ poor″ quality at the downstream throughout the study period .

V. References

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Table 1: CCME WQI and status of water quality (CCME , 2001).

CCME WQI Categories	**Water quality status**
Excellent (CCME WQI Value 95 – 100)	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine.
Good (CCME WQI Value 80 – 94)	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
Fair (CCME WQI Value 65 – 79)	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
Marginal (CCME WQI Value 45 – 64)	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
Poor (CCME WQI Value 0 – 44)	Water quality is almost always threatened or impaired; conditions usually depart from natural of desirable levels.

Table 2: The data used in calculation of WQI of Euphrates River at the study period.

Date	pH	Turbidity NAU	TSS mg/L	DO mg/L	BOD mg/L	TDS mg/L	$PO_4^{=}$ mg/L	HCO_3^- mg/L	Cl^- mg/L	$SO_4^{=}$ mg/L	FC #/mL	TN mg/L
Nov.08	8.14	***15.83**	12.66	11.12	**1.25**	**1803.90**	0.018	138.90	124.27	**635.09**	**2**	**1.07**
Dec.08	8.40	**14.42**	11.56	10.52	**1.44**	**1875.00**	**0.138**	156.90	139.27	**428.90**	**2**	0.99
Jan.09	8.85	**17.21**	13.77	11.59	**1.61**	**612.54**	**0.096**	155.27	152.54	**356.18**	**1**	0.94
Feb.09	8.20	**7.69**	6.15	9.84	**1.15**	**613.90**	0.016	148.90	150.71	**426.50**	**2**	**1.08**
Mar.09	8.32	**11.03**	8.82	8.71	2.11	**687.36**	**0.096**	142.72	180.45	**464.45**	**2**	0.75
Apr.09	8.32	**6.48**	5.18	7.68	2.00	**5886.36**	0.043	**319.09**	210.00	**459.27**	**3**	0.70
May09	8.43	**11.30**	9.04	7.32	2.56	**693.00**	0.010	132.45	**285.69**	**587.63**	**3**	0.61
June09	8.22	**6.97**	5.49	6.90	6.26	**729.81**	0.013	131.63	**283.84**	**629.72**	**3**	0.53
The objectives	6.5-9.0	5	500	5	2	500	0.05	200	250	**250**	**0**	1

***Bolded values do not meet the objective.**

Table 3: Variation of WQI of Euphrates river with number and type of used variables .

Number of variable	Type of variables	Level and status of WQI
6	PH , TSS, DO, BO,PO $_4^{=}$, FC	61.09 Marginal
9	PH , TSS,DO,BOD,PO $_4^{=}$ FC,T,CU,TN	49.34 Marginal
12	PH , TSS, DO,BOD, Po $_4^{=}$, FC, TN, TDS,HCO $_3^{-}$ Cl^- , SO $_4^{=}$, Turbidity	49.95 Marginal
15	PH, TSS, DO, BOD, $PO_4^{=}$, TN, HCO $_3^{-}$, Cl^- , FC, T, Na, K, Ca, Cu, Turbidity	54.65 Marginal

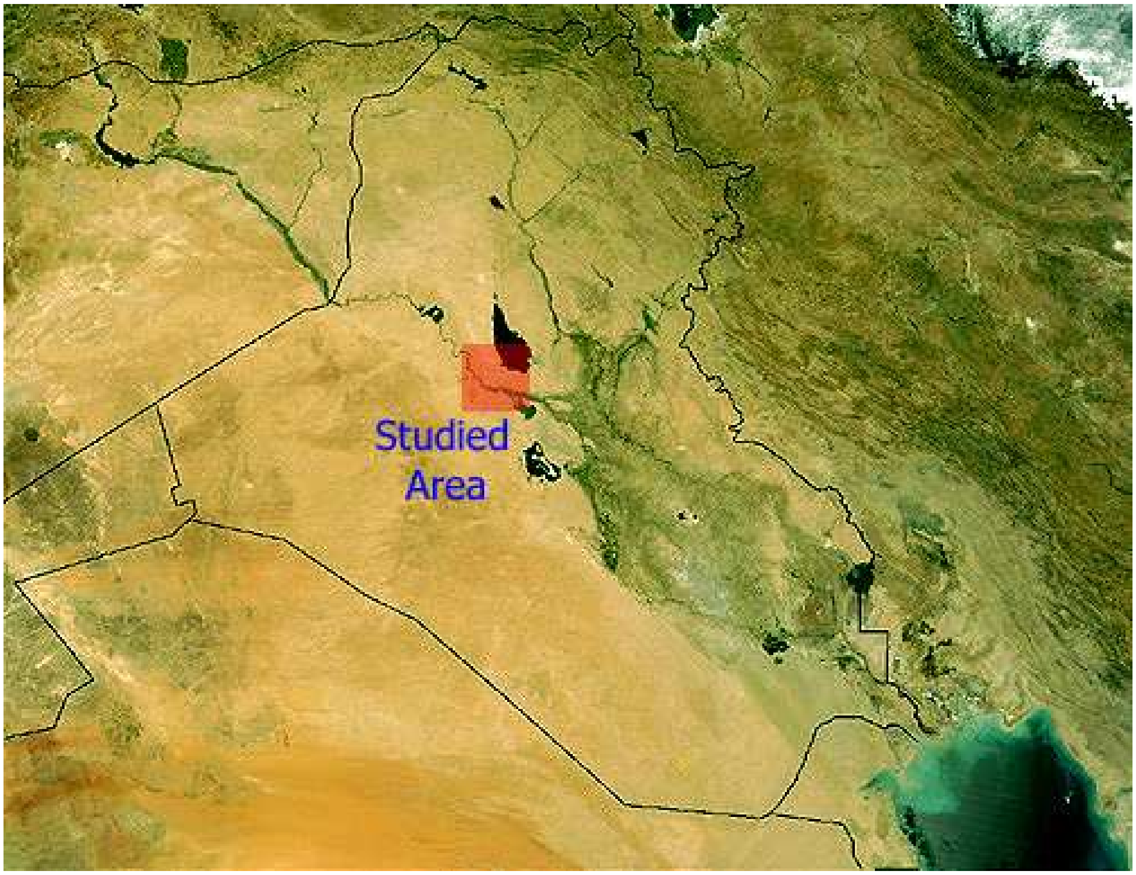

Figure 1: Location map of the studied area.

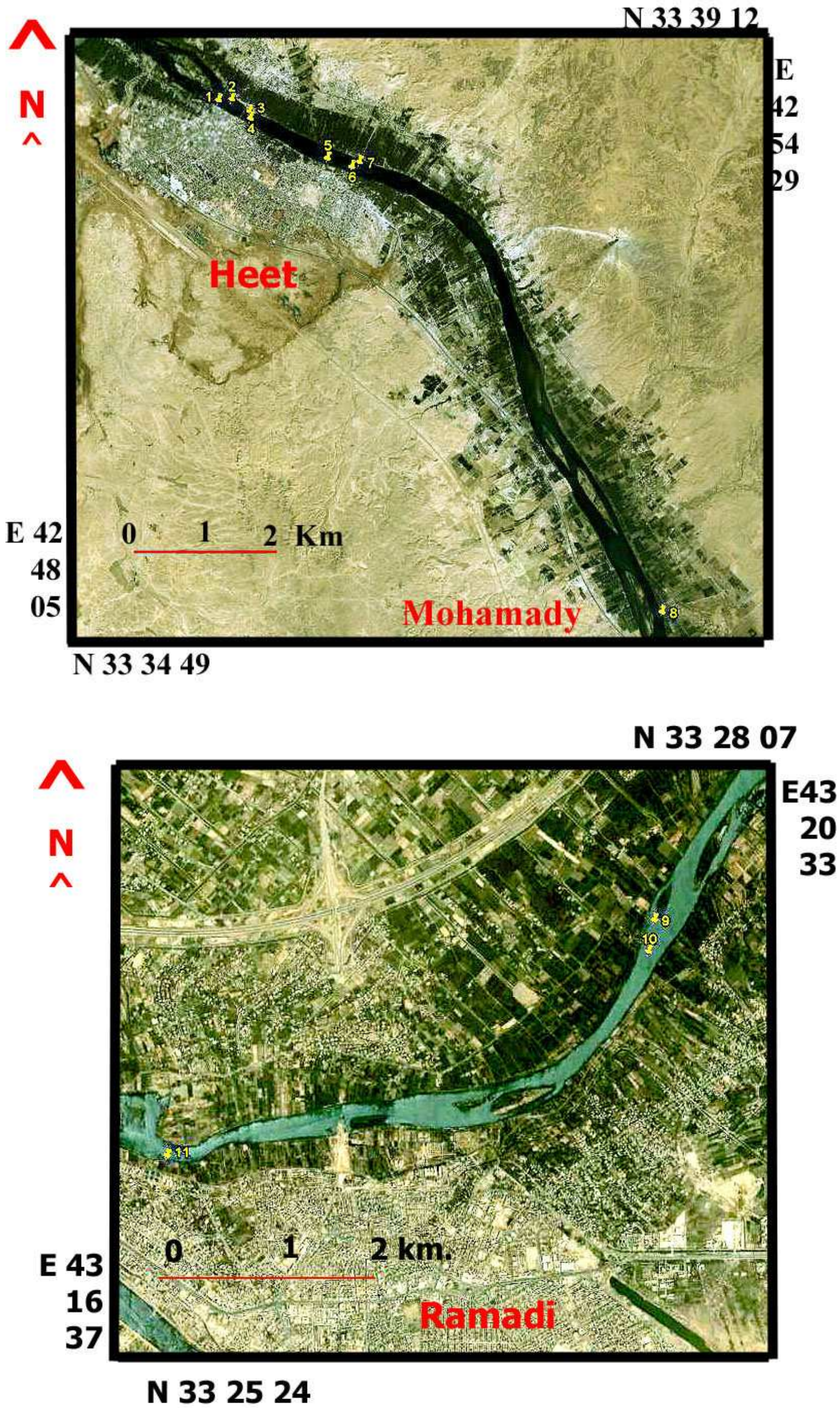

Figure 2: Locations of the sampling stations

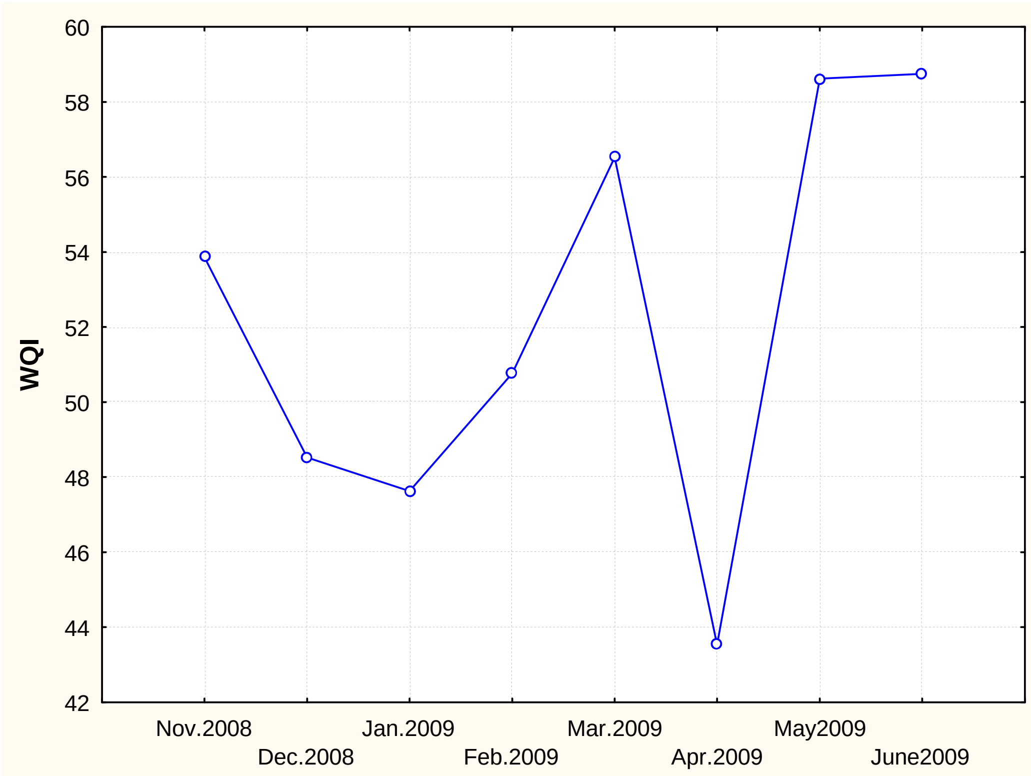

Figure 3: The monthly variation of WQI of Euphrates River.

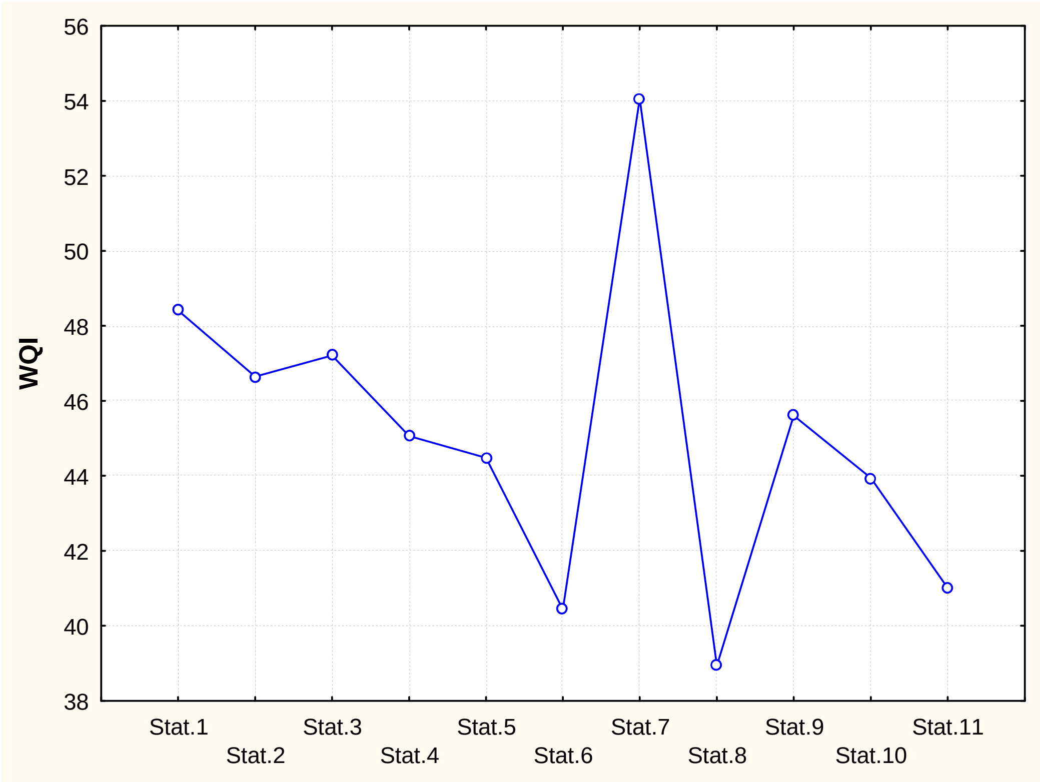

Figure 4: Spatial variation of WQI of Euphrates River within the study area.