Water Quality Index of Euphrates River Near Al- Musayyab Power Plant

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Abstract

This research deals with analyzing samples of water from the Euphrates River before and after (50m, 200m, 500m, and 1000m from the outflow)the power plant of AL-Musayyab. A Water Quality Index (WQI) analysis was performed, which is a helpful tool for rapid estimation of the quality of any water resource.. Water quality of the river was classified into good, poor, very poor, and unsuitable for drinking, based on physico-chemical parameters such as pH, total hardness (TH), and concentrations of the major ions of calcium (Ca^{+2}), sodium (Na^+), magnesium (Mg^{+2}), potassium (K^+), nitrate ($NO3^{-2}$), sulphate ($SO4^{-2}$), phosphate ($PO4^{-2}$), and Chloride (Cl^-), which indicate the extent of pollution. The study shows the deterioration of water quality, with the main candidate causes of being the direct discharge of the power plant into the river and high anthropogenic activities.

Keywords: Water Quality Index, Pollution, River Euphrates, Industrial Waste Contaminated River.

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دليل نوعية المياه لنهر الفرات بالقرب من محطة كهرباء المسيب

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الخلاصة

يتضمن البحث دراسة تحليلية لعينات من نهر الفرات قبل وبعد محطة كهرباء المسيب الحرارية. حيث تم دراسة دليل نوعية المياه والتلوث او التغيرات في نوعية المياه. دليل نوعية المياه أداة مفيدة في التقييم السريع لنوعية أي مصدر مياه .أخذت العينات قبل وبعد منطقة الطرح للنهر على ابعاد 50م, 200م, 500م, 1000م. نوعية مياه النهر تم تصنيفها الى جيدة و سيئة و سيئة جدا وغير مناسبة للشرب . تقييم دليل نوعية المياة لنهر الفرات شملت العوامل الفيزيائية والكيميائية مثل الأس الهيدروجيني والعسرة الكلية وتركيز الايونات الرئيسية كل من ايون الكالسيوم والصوديوم والمغنيسيوم والبوتاسيوم والنترات والكبريتات والفوسفات والكلورايد والتي تبين امتداد التلوث. اظهرت الدراسة أن المسبب الرئيسي في تدهور نوعية المياة في هذه المنطقة هو التصريف المباشر لمخلفات المحطة الكهربائية و كذلك النشاطات البشرية العالية.

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Introduction

Water is considered as one of the most significant resource that supports ecosystems, playing vital roles in various uses such as drinking and industry [1]. In the last decades, the quality of natural water surfaces and ground water has been changed due to urbanization, industrial activities, etc., which usually cause pollution that has serious impacts on the physical and chemical properties of water. As a result, the aquatic ecosystem interactions, such as the delicate food web, can be seriously altered. In addition, the polluted water is well known to have extremely deleterious impacts on the health of the residing communities consuming this water for various purposes [1]. A variety of physical, chemical

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and biological criteria can be used to determine the water quality of any specified origin. In case that the measured values of these parameters are exceeding the defined limits, the consumed water is undoubtedly harmful to human health [2]. Therefore, water source suitability for human consumption has been depicted in terms of WQI, which is known as one of the most efficient approaches to rank water quality into categories, such as good, poor, unsuitable for drinking, and others. These terms are publically used because they are easy to understand. Horton was the first scientist who introduced the WQI at 1965, then several researchers employed it for evaluating the quality of diverse water resources [3]. It is worth mentioning that the quality of water samples is widely evaluated by the WQI around the world, including that of rivers and other surface waters [4, 5] as well as groundwater and aquifers [6, 7]. In Iraq, several studies were conducted in 2012 to assess the quality of surface water. Shaymaa and Ayad [8] conducted a study to determine the water quality of the river Euphrates. Abbas and Ali [9] determined the water quality of Diyala River and demonstrated that it represented a contamination source due to its highly contaminated water. Ahmad WQI of Qalyasan Stream in the city of Sulaimania / Kurdistan, Iraq was also estimated, whereas another study was reported in relation to Tigris River's raw and processed water quality inside Baghdad [11]. Water quality assessment of Rawanduz River and Gali Ali Beg stream were also investigated [12]. The present study aims to evaluate changes in water quality of Euphrates River before and after Al-Musayyab thermal power plant using WQI, based on physical-chemical parameters, as a tool to determine water suitability for drinking purposes.

Study area

The study area is located at the Euphrates river near Al-Musayyab power plant, in the northern border of Babylon Governorate, Central Iraq, within the Mesopotamian basin of the unstable shelf [13] between 32˚50'50" N 44˚16'12" E. The study area is characterized by flat topography and is covered by the Quaternary deposits of the flooding periods of Tigris and Euphrates Rivers. No rock units are exposed in the area, while sedimentary rocks are covered by very thick layers of recent sediments that are up to 600 m thick [14]. Agriculture farms and villages with moderately-sized populations are distributed in the surrounding areas of the power plant.

Materials and methods

Water samples were collected from four sampling stations before and after the plant (Figure-1). Wide-mouthed plastic bottles of one-liter size were used for collecting the samples and preserved until the parameters were analyzed in the laboratory. Water samples were analyzed for the following Physico-chemical parameters: pH, , TH, and concentrations (Mg^+), (Ca^+) , (K^+), (Na^+) , $(PO4^-)$, $(NO3)$, (Cl^-) and $(SO4)$ (APHA 1998) [15].
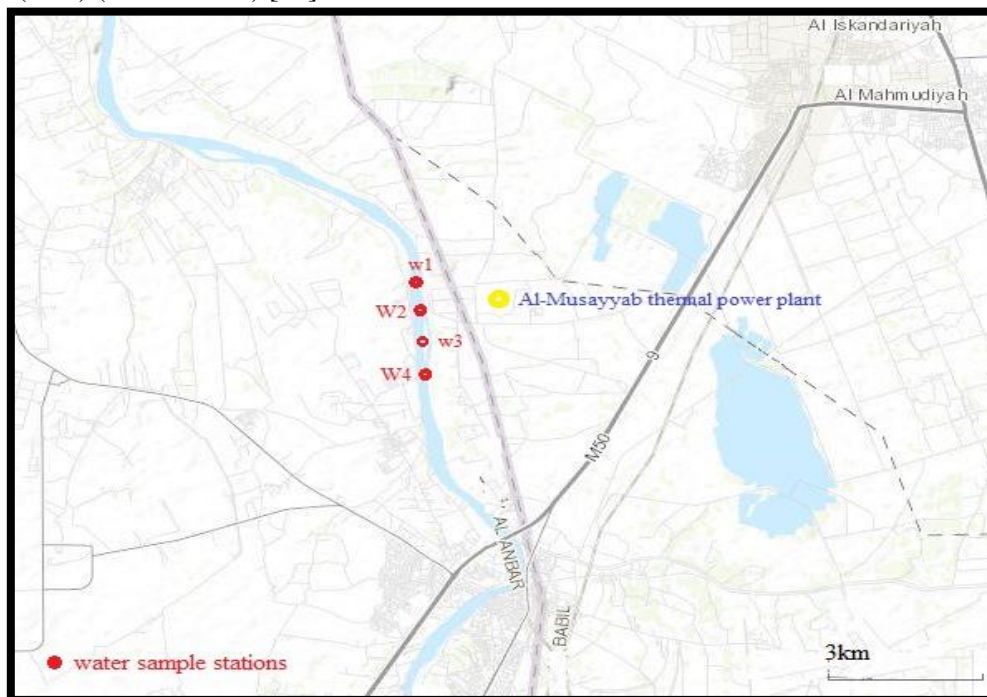

Figure 1- Study area and water sampling stations

In this study, the estimation of water quality index was based on ten significant physicochemical factors. The WQI was calculated and the quality of water was determined by means of the standards of drinking water adopted by the World Health Organization (WHO) [16], which are listed in Table-1.

Table 1-Standards for different parameters used [16]

parameter	standard
PH	7.5
T.H	500
Ca^{+2}	100
Mg^{+2}	125
Na^+	200
K^+	12
NO_3^{-2}	50
PO_4^{-2}	0.4
SO_4^{-2}	250
Cl^-	250

Water quality index determination WQI was calculated by using the Weighted Arithmetic Index method [17, 18], as expressed in the following equation:

$$Qi = \frac{Ci}{Si} * 100 \qquad \dots\dots\dots\dots (1)$$

Qi = Quality" rating of its parameter"for a total of n"water quality parameters.
Ci="Actual value of the"water quality parameter obtained"from the analysis".
Si= Suggested"standard of the water"quality parameter."
    Then the relative"(unit) weight (Wi) was"intended by a value" contrariwise proportional"to the recommended standard"(Si) for the consistent tparameter"using the next expression;"

$$Wi = \frac{1}{Si} \qquad \dots\dots\dots\dots (2)$$

where Wi = Relative(unit) weight for the parameter.
Si=Standard allowable value for the parameters.
Finally, the overall WQI was calculated by combining the quality rating with the unit weight by using the following equation:

$$WQI = \frac{\Sigma QiWi}{\Sigma\, Wi} \qquad \dots\dots\dots (3)$$

 where Qi = Quality rating.
 Wi = Relative (unit) weight.

Table 2-Water quality classification based on WQI values [19]

WQI Value	Water Quality
<50	Excellent
50 - 100	Good water
100-200	Poor water
200-300	Very Poor water
>300	Water unstable for drinking

Results

The results of the physico-chemical characterization of Euphrates river conducted in 17th November 2018 are briefed in Table-3.The results of the calculation of water quality index of sampling stations are shown in Tables- 4, 5, 6, and 7.

Table 3-Concentrations of the different parameters used in calculating the water quality index .

parameters	PH	T.H ppm	Ca ppm	Mg ppm	Na ppm	K ppm	NO_3 ppm	PO_4 ppm	SO_4 ppm	Cl ppm
Station1	8	452	96.192	47.488	4.864	1.633	14.531	1.037	204.086	175.944
Station2	7.8	650	168.336	89.568	10.59	1.32	53.344	2.879	460	314.722
Station3	8	720	184.208	97.388	4.86	1.475	9.844	0.451	583.09	279.912
Station4	8	518	140.24	59.568	4.86	1.63	11.719	0.819	133.326	335.894

Table 4-Calculation of water quality index of sampling station 1

Water quality parameters	C_i	S_i	W_i	q_i	$W_i q_i$
PH	8	7.5	0.133	106.667	14.222
T.H	452	500	0.002	90.400	0.181
Ca^{+2}	96.192	100	0.010	96.192	0.962
Mg^{+2}	47.488	125	0.008	37.990	0.304
Na^{+}	4.864	200	0.005	2.432	0.012
K^{+}	1.633	12	0.083	13.611	1.134
NO_3^{-2}	14.531	50	0.020	29.063	0.581
PO_4^{-2}	1.037	0.4	2.500	259.213	648.032
SO_4^{-2}	204.086	250	0.004	81.634	0.327
Cl^{-}	175.944	250	0.004	70.378	0.282
			$\Sigma Wi=2.77$		$\Sigma WiQi=666.036$
Water Quality Index (WQI) = Σ WiQi/ΣWi=240.47					

Table 5-Calculation of water quality index of sampling station 2

Water quality parameters	C_i	S_i	W_i	q_i	$W_i q_i$
PH	7.8	7.5	0.1333	104	13.8667
T.H	650	500	0.0020	130	0.2600
Ca^{+2}	168.336	100	0.0100	168.34	1.6834
Mg^{+2}	89.568	125	0.0080	71.66	0.5732
Na^{+}	10.59	200	0.0050	5.3	0.0265
K^{+}	1.32	12	0.0833	10.98	0.9144
NO_3^{-2}	53.344	50	0.0200	106.69	2.1338
PO_4^{-2}	2.879	0.4	2.5000	719.85	1799.6231
SO_4^{-2}	460	250	0.0040	184	0.7360
Cl^{-}	314.722	250	0.0040	125.8888	0.5036
			$\Sigma Wi=2.77$		Σ WiQi=1820.3205
Water Quality Index (WQI) = Σ WiQi/ΣWi=657.23					

Table 6-Calculation of water quality index of sampling station 3

Water quality parameters	C_i	S_i	W_i	q_i	W_iq_i
PH	8	7.5	0.1333	106.6667	14.2222
T.H	720	500	0.0020	144	0.2880
Ca^{+2}	184.208	100	0.0100	184.2080	1.8421
Mg^{+2}	97.388	125	0.0080	77.9104	0.6233
Na^+	4.86	200	0.0050	2.4320	0.0122
K^+	1.475	12	0.0833	12.2917	1.0243
NO_3^{-2}	9.844	50	0.0200	19.6875	0.3938
PO_4^{-2}	0.451	0.4	2.5000	112.6466	281.6164
SO_4^{-2}	583.09	250	0.0040	233.2360	0.9329
Cl^-	279.912	250	0.0040	111.9648	0.4479
			$\Sigma Wi=2.77$		$\Sigma WiQi=301.4030$
Water Quality Index (WQI) = Σ WiQi/ΣWi=108.82					

Table 7-Calculation of water quality index of sampling station 4

Water quality parameters	C_i	S_i	W_i	q_i	W_iq_i
PH	8.0000	7.5	0.1333	106.6667	14.2222
T.H	518	500	0.0020	103.6	0.2072
Ca^{+2}	140.24	100	0.0100	140.24	1.4024
Mg^{+2}	59.568	125	0.0080	47.6544	0.3812
Na^+	4.86	200	0.0050	2.4320	0.0122
K^+	1.63	12	0.0833	13.6111	1.1343
NO_3^{-2}	11.719	50	0.0200	23.4375	0.4688
PO_4^{-2}	0.39	0.4	2.5000	97.5000	243.7500
SO_4^{-2}	133.326	250	0.0040	53.3304	0.2133
Cl^-	335.894	250	0.0040	134.3576	0.5374
			$\Sigma Wi=2.77$		$\Sigma WiQi=262.32$
Water Quality Index (WQI) = Σ WiQi/ΣWi= 94.715					

Table-8 indicates the location and classification of water collection stations according to their own quality levels, which reveals that water quality of the selection stations ranges from "very poor to good water", based on their location before or after the power plant.

Table 8-Descriptions of the water sampling stations and classification of their water quality for samples collected in November 2018**.**

station	coordinates		Mean WQI	Description
	E	N		
Station (1)	44˚16'12"	32˚50'50"	240.47	Very poor water
Station(2)	44˚16'13"	32˚50'23"	657.23	Water unsuitable for drinking
Station(3)	44˚16'12"	32˚50'20"	108.82	Poor water
Station (4)	44˚16'14"	32˚49'59"	94.715	Good water

Discussion

According to the above WQI values at various sampling stations, there was an increasing trend in these values at the plant's downstream, indicating an increase in contamination load in the river. Pollution load increases in a river due to effluent discharges by the plants established along its course. Among all the physicochemical parameters selected for water quality index calculation, pH is a factor that regulates the appropriateness of water for many uses and the level of contamination in the watershed areas. In this study, pH values ranged from 7.8 to 8.2, falling within the acceptable surface water limits and indicating that water samples are almost neutral to sub alkaline.

Water is described as hard when it contains high levels of dissolved minerals, specifically calcium and magnesium. Hard water is not a health risk, but a nuisance because of mineral buildup on fixtures and poor soap and detergent performance [20]. The results reported by water surveys conducted in this study showed that total hardness levels were frequently higher than the minimum allowable level suggested by the WHO for drinking water"[21].

High levels of calcium and magnesium cations contribute to the elevated hardness of water. However, levels of sodium and potassium cations were within the permissible levels.

Nitrate"ion can cause methemoglobinemia in infants less than six months old if it is found in water "[22]."The mean nitrate concentration of the samples was found to be more than the allowable levels "of 50 mg /L.

High phosphate levels may imply toxicity and are largely responsible for eutrophic circumstances. Domestic wastewater with run-off detergents, industrial effluents, and fertilizers contributes to high phosphate levels in surface water [23]. The mean level of phosphate in the studied sites was higher than that specified by the limits.

Sulphate naturally exists in surface waters as SO_4^{-2}. Atmospheric precipitation and industrial discharges can also add significant amounts of sulphate to surface waters. The mean concentration of sulphate was within the tolerable limits of WHO for drinking water.

Chloride is an essential parameter for evaluating the quality of water. High concentrations of chloride indicate a higher degree of organic contamination that can occur near sewages, irrigation drains and waste outlets [22]. The mean chloride concentration was found to be at the acceptable value of 250 mg / l.

Conclusions

Over time, water quality conditions can be identified and compared by WQI. This rapid evaluation tool can be used as an environmental indicator in a variety of ways, improve awareness of general issues of water quality, evaluate the effectiveness of water quality management activities, and illustrate the need for protection practices and their effectiveness. In this study, the implementation of WQI was found to be very useful to evaluate the overall water quality along four stations upstream and downstream a power plant established at Euphrates river within Babylon Governorate.

This study concludes that, for drinking purposes, the water quality is not appropriate. The results suggested that Euphrates river's water quality is mostly very poor, ranging from very bad upstream water to unsuitable for human consumption in the downstream, indicating the effects of pollution resulting from waste materials discharged from urban activities and industrial activities.

Several recommendations could be extracted based on the results of the present study. It must be made sure that efficient water treatment measures are followed in the operating units before being established at the rivers and other parts of the environment. Analysis of heavy elements in water is necessary to determine the level of pollution generated by power plants. Water quality assessment should be conducted periodically to identify pollutants and to reduce the risk of environmental pollution.

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