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Using the Wastewater Quality Index to Assess the Compliance of Treated Wastewater with Iraqi Standards

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Abstract

The acute scarcity of water and the increasing demand for it for various purposes have become a major problem facing most countries suffering from water scarcity and limited water resources. Therefore, monitoring the quality of wastewater discharged into water sources has become an urgent necessity to reduce the pollution of these limited resources. This study used the Wastewater Quality Index (WWQI) method to assess the quality of treated wastewater discharged from the Biological Al Thaghr Treatment Plant into the Tigris River in Basra Governorate, by evaluating the plant's performance over a full year, 2023. The WQI results showed that only 36.36% of the studied period was the discharged water of good quality. The concentrations of a range of physical and chemical variables in the discharged wastewater to the water body were also compared with the Iraqi standards for this type of water. The results showed that the concentrations of most variables were within the permissible limits, except for a few that exceeded these limits, namely EC, TDS, and CL.

Keywords: Wastewater, Pollution, Evaluation , WWQI

1- Introduction

Despite the importance of water as a fundamental force in supporting systems for critical environmental issues and a cornerstone of sustainable social and economic development, the management of this vital resource is among the worst in the world. Pressure on limited water resources due to human activities resulting from rapid industrial growth, agricultural use, and the continued expansion and growth of cities has led to increased sources of water pollution, both groundwater and surface water [1].

Water, can take various forms and manifestations in nature such as rivers, lakes, groundwater, and others, serves many essential purposes. Its quality is of paramount importance to societies and the sustainability of their development [2,3].

The physical, chemical, and biological parameters of water, as well as its heavy element content, are the primary factors upon which water quality assessment depends. Therefore, considerations such as preventing contamination of water resources with untreated wastewater and proper treatment of this water prior to discharge are critical in the formulation and design of appropriate units for disposing of such types of water [4,5]. Water Pollution Indicators (WPIs) contribute to water quality assessment as tools applicable to various types of water bodies. They therefore contribute to water pollution control, monitoring, and prevention [6].

The developing countries which are naturally have limited fresh water resources facing valuable water challenges to achieve national goals and water management requirements. Recent

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studies evaluated water value, categorize the pollutants, strategize the corrective measures to conform different proposes of water use, maintain ecological health and restore the carrying capacity of the water resources [7,8].

Recently, the continued increase in demand for water has widened the gap between supply and demand, leading to increased competition among various sectors—agricultural, industrial, and domestic—for limited water resources. This ultimately leads to reduced availability of these freshwater resources [9]. Therefore, it has become imperative to provide alternative water sources to natural ones. One such alternative that can be utilized is treated wastewater, which is no less important than natural resources and must therefore be preserved and protected from pollution. [10,11]

Very large quantities of nutrients, pathogens and organic wastes put the greatest pressure on the quality of water, causing the deteriorating quality, and thus damage to various biological systems. One of the most important reasons for the presence of these large amounts of pollutants is untreated or poorly treated wastewater that is offered to water sources, whether surface or underground [12].

Wastewater treatment plants have regulatory implications for public health and the environment due to their significant impact on surface water bodies. Therefore, evaluating the performance of these plants is a challenging and very important process. This has led to the development of a monitoring tool for compliance with wastewater discharge standards, namely the Wastewater Quality Index [13].

One of the drawbacks of water quality indicators is that they may overlook some pollutants or simplify environmental complexity, but they remain a clear, easy, and accessible method for continuous monitoring[14].

When calculating the index value, it takes into consideration the various indicators for evaluating the quality and suitability of water, whether chemical, physical or biological, and reduces them to a single number with a value ranging between (0-100). It is considered a good tool for evaluating wastewater quality standards [13,15].

WWQI helps researchers monitor and study the effects and thus evaluate the water quality of freshwater bodies. It is an effective approach to the condition of freshwater bodies, ensuring that these waters are suitable for human use [16,17]. In 2018, Khudair et al. conducted a study to evaluate the efficiency of the Diwaniyah wastewater treatment plant by calculating the wastewater quality index (WWQI) of the treated wastewater discharged from the plant according to Iraqi disposal standards. The study found that the discharged water could be classified as weak to very weak, but its quality was lower than World Health Organization standards, falling into the very weak to very polluted category [18].

Issa and Al shatteri (2020) concluded that the levels of pollutions in the Diyala-Sirwan River range from light to moderate. The study was conducted using various river water indicators in different areas to determine the impact of sewage discharged from the city of Kalar on river water quality by assessing the severity of pollution [19].

Helal et al ., 2022 focused to study Wastewater Quality Index (WQI) and their suitability for irrigation and aquatic life of Tenth Ramadan and El-Obour cities and El-Khadrwia drain. The study showed that the recommended standards did not apply to the concentrations of organic pollutants. It also showed that the primary treatment contributed effectively to removing approximately 50-60% of the pollutants and indicated that the use of nanoparticles may have positive environmental effects [20].

In 2023 a study conducted by Abualhaija, the feasibility of using wastewater from the Kufranja station in Jordan for irrigation purposes was investigated using a water quality index based on national standards for the reuse of treated wastewater. The study concluded that the treated water is unsuitable for release into water resources, but that it could be used to irrigate certain types of agricultural crops 11].

Gaviria et al., 2024 used environmental regulations, WHO recommendations, and agricultural use parameters to develop a comprehensive methodology for assessing the quality of gold mining facilities in Colombia, Caldas Department. [14].

And Benkov et al., 2024 applied the wastewater quality index approach to monitor 21 wastewater treatment plants using a weighting approach for a set of water quality indicators within a single monitoring campaign. [13].

Speed and efficiency are important factors in water management within a given area. This can be achieved through water quality indicators, which have the ability to quickly and easily assess the quality of both treated and untreated wastewater; this research proposes the use of the WWQI methodology to evaluate the quality of wastewater discharged from the Al-Thaghr Biological Station to the river.

2- Study Methodology

2.1. Study Area

Al-Thaghr sewage treatment plant is located in Basra Governorate, Al-Qurna District, Al-Thaghr Sub-district, at longitude and latitude (47.4450181, 31.1452023) and serves 90% of the region's population. The wastewater entering the station is for domestic use by the region's residents; the plant does not treat industrial water or other pollutants.

2.2. Data Description

This study aims to evaluate and examine the quality of raw and treated wastewater from the wastewater biological plant of Al-Thaghr (STP). The collected and experimental data used in this study were provided from Basra Sewerage Directorate. The data collected through the study period represented the monthly average values for each parameter. All tests were conducted according to Standard Methods (2017) for the Examination of Water and Wastewater, 23rd edition.

3- Wastewater Quality Index

A set of chemical, physical, and biological properties of water can be reduced to a single, unitless number ranging from 1 to 100, which gives a comprehensive view of the quality of this water. This number is called the Waste Water Quality Index [18,21].

The weighted arithmetic water quality index method (WWQI) was applied in this study for calculating WQI by means of the following equation [17].

$$WWQI = \frac{\sum qi\,Wi}{\sum Wi} \quad (1)$$

Where: qi= quality rating scale for each parameter; Wi = unit weight of i water quality parameter

The following equation was applied for estimating the quality rating (qi)

$$qi = \left(\frac{Vi - Vid}{Si - Vid}\right) \times 100 \quad (2)$$

Where: Vi= concentration of water parameter. Vid = ideal value for i parameter (i.e. for pH, Vid = 7.0, and Vid = zero for the other parameters), and Si= standard permissible value of nth water quality parameter

The unit weight (Wi) was calculated using the following equation:

$$Wi = \frac{K}{Si} \quad (3)$$

K= constant of proportionality. It was calculated using the following equation:

$$K = \frac{1}{\sum \frac{1}{Si}} \quad (4)$$

Rating of WWQI and corresponding grade of the treated wastewater are displayed in Table 1.

Table 1. Water Quality Classification based on WWQI value

WWQI range	**Rating of wastewater quality**
0-25	Excellent
26-50	Good
51-75	Regular
76-100	Bad
>100	Very bad

4- Calculation method of water quality index

The weighted Arithmetic method was used to determine WWQI of the Al Thaghr WWTP and evaluate its performance based on the nine parameters of influent and effluent compared with the specification and Iraqi standards for effluent disposed to the river waters, tables 2 and 3 displays the descriptive data of the treatment plant, while table 4 shows a sample of the WWQI calculations.

Table 2. Descriptive data of the treated effluent wastewater characteristics of Al thagr WWTP

Parameter	Max.	Min.	Average	Limits for treated effluent*
Temperature (T) (ºC)	34.7	19		25-30
pH	7.8	6.86	7.33	6-9.5
Total dissolved solids (TDS) (mg/L)	3292	1288	2017	1500
Total suspended solids (TSS) (mg/L)	50.4	8	19.53	60
Electrical conductivity (EC)(µm/cm)	5100	2290	3259	400
Chemical oxygen demand (COD) (mg/L)	84	25	55.12	100
Biochemical oxygen demand (BOD) (mg/L)	33	8	16	40
Chloride (CL) (mg/l)	1082	346	594.7	600
Ammonia (NH_3)(mg/l)	6.77	0.33	3.42	10
Phosphate (PO_4) (mg/l)	5	Nil	2.47	3

Table 3. Descriptive data of the untreated influent wastewater characteristics of Al thagr WWTP

Parameter	Max.	Min.	Average	Limits for treated effluent*
Temperature (T) (ºC)	35	18.9	26.9	25-30
pH	7.83	6.8	7.3	6-9.5
Total dissolved solids (TDS) (mg/L)	3246	1246	1987.81	1500
Total suspended solids (TSS) (mg/L)	624	39.6	140.5	60
Electrical conductivity (EC)(µm/cm)	5130	2360	3189.09	400
Chemical oxygen demand (COD) (mg/L)	214	100	163.85	100
Biochemical oxygen demand (BOD) (mg/L)	139	65	92.5	40
Chloride (CL) (mg/l)	896	396	558.36	600
Ammonia (NH_3)(mg/l)	14.9	6.77	10.08	10
Phosphate (PO_4) (mg/l)	6.7	0.77	3.67	3

Table 4 Sample of calculation of the wastewater quality index.

Parameters	Ci	Si (IQS)	Wi	qi	Wi*qi
pH	7.33	7.5	0.215	66	14.19
TSS (mg/L)	19.53	60	0.027	32.55	0.88
COD (mg/L)	55.12	100	0.0161	55.12	0.88
BOD (mg/L)	16	40	0.04	40	1.6
TDS (mg/L)	2017	1500	0.0011	134.5	0.134
EC (µm/cm)	3259	400	0.004	814.75	3.26
CL (mg/L)	594.7	600	0.0027	99.12	0.27
NH_3 (mg/L)	3.42	10	0.616	34.2	21.07
PO_4 (mg/L)	2.47	3	0.537	82.33	44.21
Total			1.459		86.494
Overall WWQI					59.28

5- Results And Discussion

5.1- Effluent physiochemical parameters

Table 1 shows the average values of physical and chemical parameters of the treated wastewater discharged from the study station during the study period. Almost all parameters were within the Iraqi specifications for treated wastewater discharged to rivers and water bodies, except for EC, TDS, and CL, which were outside the specifications in most months. The average BOD, COD, and TSS concentrations were 16, 55.12, and 19.53, respectively. These are considered within the Iraqi specifications for treated wastewater discharged.

5.2- WWQI during the study period

Table 5 and fig. 1 classifies the WWTP influent and effluent based on the wastewater quality index. The (WWQI) variation of AlThagar WWTP during year 2023 is also displayed. The monthly variation of WWQI values indicates that in 36.36% of the months, the effluent quality is within the class of good water according to the Iraqi standards and the same percent (36.36%) within the class regular while18.18% of bad category and 9.1% of the effluent wastewater classifies as very bad. The study concluded that 64.64% of the time period saw poor quality water discharged into the river, according to the results of the water quality index. Therefore, it is preferable not to discharge it into the river or other water bodies due to its negative environmental impact on the water and its consumers and aquatic life.

Table 5 classifies the effluent and effluent quality according to the calculated WWQI.

Month	Influent		Effluent	
	WWQI	Class	WWQI	Class
Feb.	127.1	Very bad	69.95	Regular
March	80.6	Bad	101.2	Very bad
April	124.2	Very bad	27.05	Good
May	118.5	Very bad	62.25	Regular
June	76.3	Bad	34.6	Good
July	98.9	Bad	48.24	Good
August	148.3	Very bad	77.56	Bad
September	157.1	Very bad	63.3	Regular
October	117.2	Very bad	78.3	Bad
November	78.4	Bad	40.25	Good
December	83.7	Bad	53.4	Regular

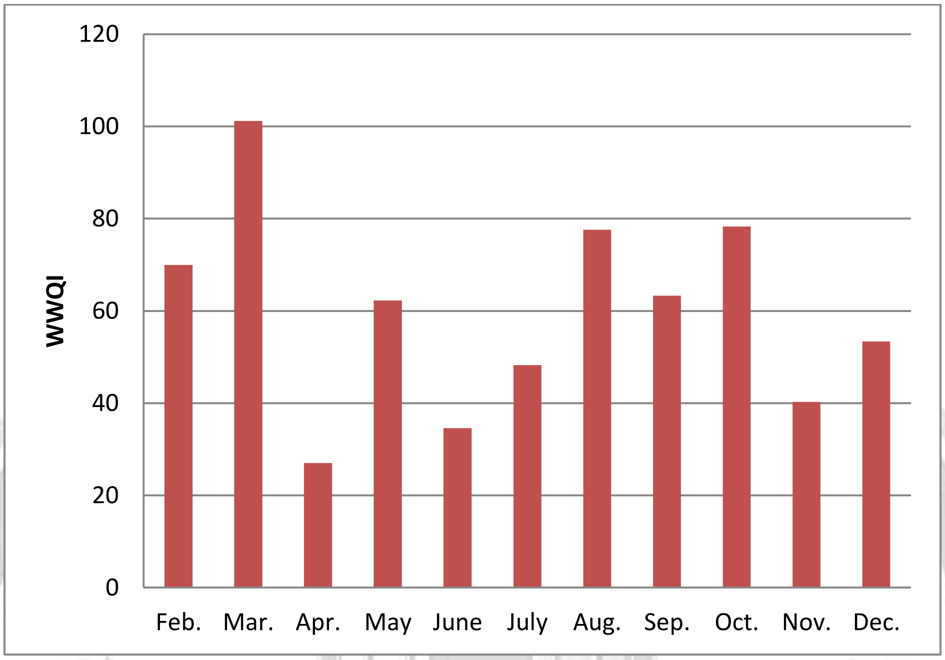

Fig. 1 WWQI variations

6- Conclusion

Continuous assessment and monitoring of wastewater treatment plants significantly contributes to increasing their operational efficiency and protecting water resources and the environment from the harmful effects of discharged wastewater into these water bodies. Using the Water Quality Index (WQI) method is an easy, successful, and effective way to monitor and continuously assess the quality of discharged water from these plants. The study found that approximately 64.64% of the WQI values were outside the required specification limits for discharged wastewater, ranging from normal to very poor, while only 36.36% were of good quality. Comparison of the concentrations of treated wastewater variables with the Iraqi specification also showed that the concentrations of most variables were within the specified limits, with the exception of EC, TDS, and CL. Therefore, the plant requires further monitoring and evaluation of the quality of the discharged water as well as further treatment to ensure the safe use of the river water into which it is discharged.

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استخدام مؤشر جودة مياه الصرف الصحي لتقييم مدى توافق مياه الصرف الصحي المعالجة مع المعايير العراقية

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الخلاصة

اصبحت الندرة الحادة للمياه والطلب المتزايد عليها لاغراض مختلفة مشكلة رئيسية تواجه معظم البلدان التي تعاني من ندرة المياه ومحدودية الموارد المائية, لذلك اصبحت مراقبة جودة مياه الصرف الصحي المصرفة في مصادر المياه ضرورة ملحة للحد من تلوث هذه الموارد المحدودة. استخدمت هذه الدراسة طريقة مؤشر جودة مياه الصرف الصحي (WWQI) لتقييم جودة مياه الصرف الصحي المعالجة المصرفة من محطة معالجة الثغر البايلوجية الى نهر دجلة في محافظة البصرة، من خلال تقييم اداء المحطة على مدار عام كامل، 2023، اظهرت نتائج مؤشر جودة مياه الصرف الصحي ان 36.36% من فترة الدراسة كانت فيها مياه تصريف ذات نوعية جيدة. كما تمت مقارنة تركيزات مجموعة من المتغيرات الفيزيائية والكيميائية في مياه الصرف الصحي المصرفة الى المسطح المائي بالمعايير العراقية لهذا النوع من المياه. اظهرت النتائج ان تركيزات معظم المتغيرات كانت ضمن الحدود المسموح بها، بأستثناء عدد قليل منها تجاوز الحدود وهي .EC, TDS, CL

الكلمات الدالة:– مياه الصرف الصحي، التلوث، تقييم، مؤشر جودة نوعية مياه الصرف الصحي.