EVALUATION THE WATER QUALITY OF AL-RUSAFA TREATMENT PLANT IN BAGHDAD CITY / AL-RUSAFA SIDE USING SEVERAL WATER QUALITY INDICES

Ahmed Amer Shanoon*

College of Engineer, Al-Nahrain University, Baghdad, Iraq

st.ahmed.amer@ced.nahrainuniv.edu.iq

Prof. Dr. Jabbar H. Al-Baidhani

College of Engineer, Al-Nahrain University, Baghdad, Iraq

Reception: 06/12/2022 **Acceptance**: 22/01/2023 **Publication**: 08/02/2023

Suggested citation:

A. S., Ahmed and H. A., Jabbar. (2023). **Evaluation The Water Quality of Al-Rusafa Treatment Plant in Baghdad City / Al-Rusafa Side Using Several Water Quality Indices**. *3C Tecnología. Glosas de innovación aplicada a la pyme, 12(1)*, 176-189. https://doi.org/10.17993/3ctecno.2023.v12n1e43.176-189

ABSTRACT

The present study was conducted drinking water treatment plant located in districts which is (Al-Rusafa) in Baghdad city. The study aims to assess the water quality produced from the above plant using various water quality indices. Twelve physical and chemical parameters have been tested which are pH, turbidity, electrical conductivity, calcium, magnesium, chloride, total hardness, alkalinity, sulfate, sodium and total dissolved solids. Five different approaches and methodologies of water quality indices were applied to get the level of pollution during a period of nine months, starting from November 2021 until July 2022.The values WAV WQI for water treatment pant indicate that the water quality was good. Also, the results of the MNE WQI showed that water treatment plant produced clean water, but Al-Rusafa treatment plant in April, the water was very clean. The values of (weighted method) indicated that the water quality for water treatment plant was good. It was found that water treatment plant studied gives excellent quality using based on values of CCME and BCWQI indices. It is found that the values of all chemical and physical parameters are within Iraqi standards. Finally, in the present study, many statistical equation were found for the purpose of calculating the water quality index for water treatment plant studied with a proper coefficient of determinations.

KEYWORDS

Water Quality Indices, WAV WQI, water treatment plants, CCME, BCWQI.

PAPER INDEX

https://doi.org/10.17993/3ctecno.2023.v12n1e43.176-189

INTRODUCTION

Water is a valuable natural resource that we utilize for drinking and a variety of other reasons in our daily lives. [1]. Safe drinking water is essential for human health around the world; as a universal solvent, water is a primary source of protection against contamination and illness, according to the World Health Organization (WHO) Water-borne diseases account for 80% of all diseases, and drinking water in many countries does not satisfy WHO criteria [2], with 3.1 percent of deaths attributed to the unclean and poor quality of water. [3]. Water pollution occurs when unwanted contaminants enter water, altering its quality and posing a threat to the environment and human health. [4]. Some drinking water supplies have been contaminated with germs, viruses, heavy metals, and salts as a result of insufficient treatment and management of waste industrial outputs. [5] Diseases such as cholera, dysentery, and typhoid are caused by a lack of safe drinking water and proper sanitation measures, and millions of lives are lost each year in impoverished countries [6]. Water is required not only for metabolic systems in the human body, but also for other activities related with human life, such as distilled water for laboratories, medical factories, minerals in drinking water, industries, agricultural, aquatic cultures, and other similar activities [7]. The WQI can be defined as a mathematical tool transforming large quantities of data obtained from physical and chemical properties of water into a single number representing the level of water quality (Bharti and Katyal, 2011) [14]. Water quality is determined by its physical, chemical, and biological characteristics. Before using water for different intended uses, such as potable, agricultural, recreational, and industrial water utilizations, it is vital to determine the water's quality. It's critical to establish water quality metrics in order to assess the condition, quality, and level of contamination of surface water. Processing related data is necessary, and professionals should be shown the outcomes. Using water quality indicators is one of the simplest ways to evaluate current water quality conditions [10]. A need for all living things as a result, "no water, no life" is correct [9]. As a result, the goal of water treatment is to deliver water that is as close to pure as possible. Depending on the source of water, the degree of contamination, and the desired water quality, this treatment may be traditional or advanced. All water treatment plants in Iraq are conventional, and they strive to remove suspended and pathogenic contaminants. Sedimentation and filtering with coagulant assistance are employed to remove suspended and colloidal particles in these traditional plants, and chlorine is used to kill pathogens. After the water had went through the treatment process, multiple tests were carried out to measure its parameters and compare them to standards in order to assess its quality and determine whether it fulfilled the requisite criteria. Physical, chemical, and biological factors are all tested in this water.

The Tigris river is Baghdad's primary source of drinking water; yet, in recent years, there has been a rise in wastewater and direct Tigris river discharge. Furthermore, the presence of antibiotics in drinking water, in addition to other contaminants, was discovered [8], As a result, one of the most important resources is water.The research on green ecological agriculture management is of great significance to the development of ecological agriculture and the solution of various drawbacks and

https://doi.org/10.17993/3ctecno.2023.v12n1e43.176-189

crises brought by modern agriculture. However, in the current e-commerce sales, the safety and quality of agricultural products cannot be presented to customers. Based on this, in our research, we build an information-based digital management platform, which includes developed languages, frameworks and database. In the digital information management platform, we track and monitor the agricultural product information of green ecological agriculture in Northeast China throughout the whole process, so as to ensure the safety and quality of the agricultural products during the sale of the agricultural products on the e-commerce platform. In addition, we also discussed the economic benefits of this digital information platform for green ecological agriculture.

CONSTRUCTION OF INFORMATION DIGITAL MANAGEMENT PLATFORM

In order to better understand the situation of green ecological agriculture in Northeast China, this chapter mainly introduces the development languages, development frameworks and tools used in the electronic platform of agricultural products, and gives a brief introduction to them according to the situation of green ecological agriculture in Northeast China. The advantages and reasons for selection are analyzed one by one. These theories or tools include: languages, frameworks, and databases.

It is necessary to continually studying the water quality, because it is greatly affects human health. For the purpose of evaluating the level of drinking water quality in the city of Baghdad, more than one water quality index has been used and selected plant on the Rusafa side, which is: AL-Rusafa.

STUDY AREA AND METHODS

The present study was conducted to evaluate the treatment efficiency of water treatment plant in the city of Baghdad on the Rusafa side which is :(AL-Rusafa) using five indices of water quality. The source of raw water of these plant is the Tigris river.

Samples of drinking water were collected from plant studied for the period from November 2021 to July 2022. Twelve parameters were used for calculating the water quality index. These parameters are: pH, turbidity, electrical conductivity, calcium, magnesium, chloride, total hardness, alkalinity, sulfate, sodium and total dissolved solids. The Iraqi recommended Guidelines for drinking water specifications are presented in Table 1.

1. MEASUREMENT OF WATER QUALITY INDEX

The most general characteristic of the present study is the use of several water quality indices in order to ascertain the level of pollution in sone water treatment plant in the Baghdad city Al- Rusafa side.The water quality indices used in the present study are as follows:

https://doi.org/10.17993/3ctecno.2023.v12n1e43.176-189

1.1. WEIGH AVERAGE METHOD WAV (WQI)

The WQI index can be determined by the following steps [11]:

1) In this method each parameter has been given a relative weight (Wi).
2) Computing the quality rating scale (qi) for each parameter by using the following equation:

$$qi=(Ci/Si)100 \quad (1)$$

Where:

qi= quality rating scale

Ci= concentration of each parameter in each water sample in (mg/L).

Si=Iraqi drinking water standards for each chemical parameter.

3) Computing the sub index of each parameter by using the following equation:

$$SIi=Wi \times qi \quad (2)$$

Where

SIi= is the sub index of each parameter

$$WQI = \sum SIi \quad (3)$$

1.2. THE MINISTRY AND ENVIRONMENT METHOD MNE WQI

The second water quality index is the method which is adopted by Ministry of Nature and Environment (MNE) of Mongolia [12]. In this method the number of parameters has been taken into account and all the parameters have the same weight. The selected parameters included (Ca^{+2}, Mg^{+2}, TH, Cl^-, Na^+, SO_4^{-2}, Alk, Fe^{+3} and TDS).

$$WQI = \sum(Ci/Si)/n \quad (4)$$

Where:

n= is the number of parameters

1.3. WATER QUALITY INDEX

In order to calculate the Water Quality Index, the following steps were used:

Weighting: The word weighting implies relative significance of each of the factor in the overall water quality and it depends on the permissible level in drinking water as suggested by Iraqi standard. Factors which have higher permissible limits are less harmful and have low weightings [13].

$$Wi = K/Sn \quad (1)$$

Wi - Unit weight of chemical factor, K - constant of proportionality and is given as:

$$K=1/(1/Vs1+1/Vs2+ \ldots\ldots\ldots +1/Vsn) \quad (2)$$

https://doi.org/10.17993/3ctecno.2023.v12n1e43.176-189

Vsi - standard value of ith parameter

Rating scale: Each chemical factor has been assigned a water quality rating to calculate WQI.

$$Qi = 100\ [(Va-Vi)/\ (Vs-Vi) \qquad (3)$$

Where,

Qi = Water quality for each parameter (i)

Va - average of measured values in the water sample for three months at one place

Vs - Standard value of ith parameter

Vi - ideal value for pure water (0 for all parameters except pH)

The above equation becomes:

$$Qi=100(Va/Vs) \qquad (4)$$

For pH: The ideal value = 7.0; Max. Permissible value = 8.5,

$$QpH = 100\ [(Va-7.0)/\ (8.5-7.0)]$$

$$WQIi=Qi*Wi \qquad (5)$$

$$\text{Water Quality Index (WQI)} = [\Sigma\ QiWi)/\Sigma Wi\ ] \qquad (6)$$

ΣWi = total unit weight of all chemical factors.

1.4. THE CCME WQI INDEX:

In the present study CCME WQI was used to calculate the water quality. This index can be determined as follows:

The F1 is called Scope which represents the percentage of variables that do not meet their objectives at least once during the interval under consideration ("failed variables"), relative to the total number of variables measured:

F1=[(Number of failed variables)/(Total number of variables)]*100

F2 is called Frequency which represents the percentage of failed tests :

F2=[(Number of failed tests)/(Total number of tests)]*100

F3 is called Amplitude, which represents the deviations of the failed tests from their objectives. It is determined as follows:

The term "Excursion" represents the number of times that certain concentration is different from the objective. When the value of the test is less than the objective, Excursion is given by:

Excursion=[(Failed Test value)/Objective]-1

When test value is greater than the objective, Excursion is given by:

Excursion=[Objective/(Failed Test value)]-1

https://doi.org/10.17993/3ctecno.2023.v12n1e43.176-189

The sum of exertions of individual tests divided by the total number of tests is called normalized sum of excursions (*nse*) and is computed as follows:

$$nse = \left[\frac{\sum_{i=1}^{n} \text{Excursion}}{\text{Failed Test value}} \right] - 1$$

F3 is a function of nse and is given by:

$$F3 = \left[\frac{\text{nse}}{0.01 + 0.01\text{nse}} \right] - 1$$

Finally CCME WQI is calculated as follows:

$$CCMEWQI = 100 - \left[\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right]$$

The water quality is ranked according to CCME WQI as stated in Table(Bharti and Katyal, 2011)

1.5. BRITISH COLUMBIA WATER QUALITY INDEX (*BCWQI*).

This index was developed by the Canadian Ministry of Environ-ment as an increasing index. For water quality evaluation, where water quality parameters are measured and their violation is determined by comparison with a predefined limit. The *BCWQI* makes possible the classification on the basis of all existing measurement parameters(15). The formula is expressed as:

0.5

$$BCWQI = \left[\frac{F_1^2 + F_2^2}{1.453} \right]$$

Where: *F*1 (scope) = number of the non-succeeded varia-bles to the total number of the variables; *F*2 (frequency) = number of the unsuccessful tests to the total number of tests.

$$F1 = \frac{NF}{TNV} * 100$$

$$F2 = \frac{NFT}{TNT} * 100$$

Where: *NF* = number of the failed variables, *TNV* = total number of variables, *NFT* = number of the failed test; *TNT* = total number of the tests.

In the *BCWQI* formula 1.453 is the constant used to give confidence to the scale index number from 0 to 100. The degree of the confidence in the *BCWQI* depends on the repeated sampling procedure [POONAM 2013].

https://doi.org/10.17993/3ctecno.2023.v12n1e43.176-189

In order to calculate the *WQI*, the Iraqi drinking water standard values corresponding to the measured parameters were used, as shown in Table 1.

Table 1. Iraqi drinking water standards [17],[18],[19],[20],[21],[22],[23]

parameter	unit	Iraqi standard
pH	-	6.5-8.5
Alkalinity	mg/L	125-200
Total Hardness as CaCO3	mg/L	500
Magnesium (Mg^{+2})	mg/L	100
Calcium (Ca^{+2})	mg/L	150
Sodium (Na^{+})	mg/L	200
Chloride (Cl-)	mg/L	350
Sulphate SO_4^{-2}	mg/L	400
Turbidity	NTU	5
Conductivity	µs/cm	2000
TDS	mg/L	1000

Table 2. Water quality classification based on WAV method

WQI value	Water Quality
0-25	Excellent
26-50	Good water
51-75	Poor water
76-100	Very poor water
>100	Water unsuitable for drinking

Table 3. Water quality classification based on MNE method

WQI value	Water Quality
≤0.3	Very clean
0.31-0.89	clean
0.9-2.49	Slightly polluted
2.5-3.99	Moderately polluted
4-5.99	Heavily polluted
≥6.0	Dirty water

Table 4. Water quality index scale

WQI	Description
0-25	Excellent
26-50	Good
51-75	Moderately polluted
76-100	severely polluted
>100	unfit for human consumption

Table 5. The water quality is ranked according to CCME and BCWQI WQI as stated.

CWQI Categories	Ranks
95-100	Excellent
80-94	Good
65-79	Fair
45-64	Marginal

RESULTS AND ANALYSIS

The values of WAV WQI index of water treatment pant are between (29.91-36.98) for treated water, and those results showed that indicators of treated water of water treatment plant studied were good, while the highest value was (36.98) in January due to the high concentration of Cl- and Mg+2. Also, the results showed that the values of the MNE WQI of water treatment plant studied are between (0.298-0.35) for the treated water and all the values indicated that the treated water is clean, but gives very clean according to MNE method classification in June month, while the highest value was (0.35) in January due to the high concentration of Cl- and Mg+2. The values of index of (weighted method) ranged between (33.19-48.44) for the treated water. The results showed that all index values of treated water of water treatment plant studied were good, according to WQI method classification. The highest value found was(48.44) in July, due to the high concentration of TH,Ph and Na. The obtained value of the Canadian index was (99.99) for the treated water for all months studied, and the such value indicates that the treated water is excellent according to CCME method classification. Also, the value of the British index was (100) for the treated water for all months studied, and such value indicates that the treated water is excellent according to BCWQI method classification. The statistical program which is called STATISTICA,version (25) was used concluding statistical equations of water quality index in terms of time for all plant studied. The coefficient of determination (R^2) is calculated to find the degree of credibility of the equations obtained, which is as follows of Al-Rusafa Water Treatment Plant as show in the figer.

https://doi.org/10.17993/3ctecno.2023.v12n1e43.176-189

In which, WAV is,and t is in(month).The cofficent of determination R^2 is equal to 0.855.

$$WAV=42.45-5.18\ t+0.71\ (t)^2-0.03\ (t)^3 \quad (1)$$

In which, MNE is,and t is in(month).The cofficent of determination R^2 is equal to 0.801.

$$MNE=40.08-4.47\ t+0.67\ (t)^2-0.03\ (t)^3 \quad (2)$$

In which, WQI is,and t is in(month).The cofficent of determination R^2 is equal to 0.709.

$$WQI=47.8-9.02\ t+2.03\ (t)\ 2-0.11\ (t)3 \quad (3)$$

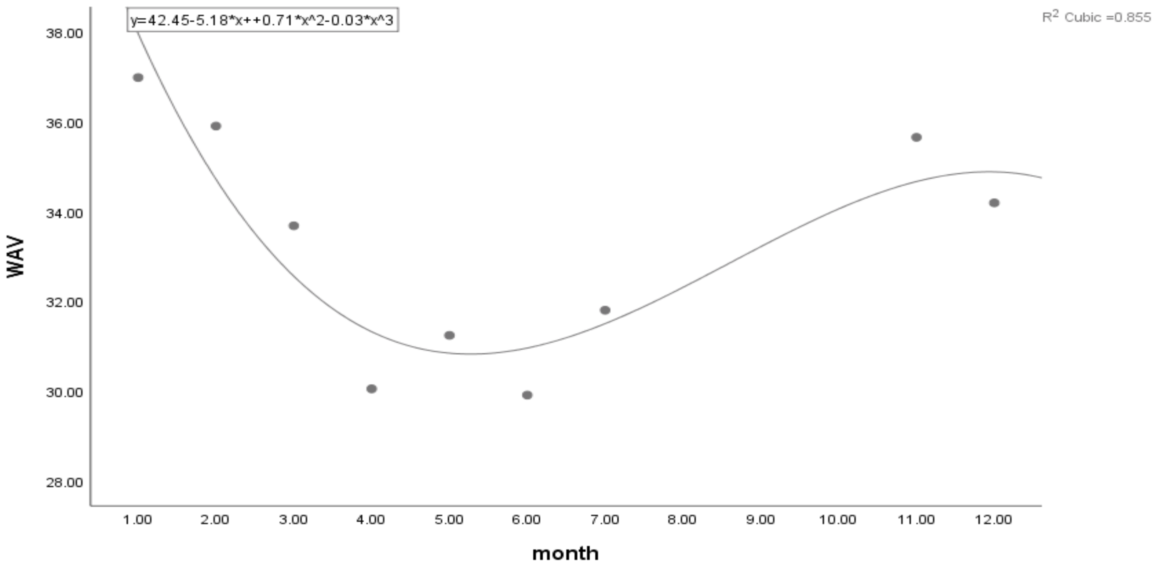

Figure. 1. Statistical Relationship of WAV Index and Time for Al-Rusafa Water Treatment Plant.

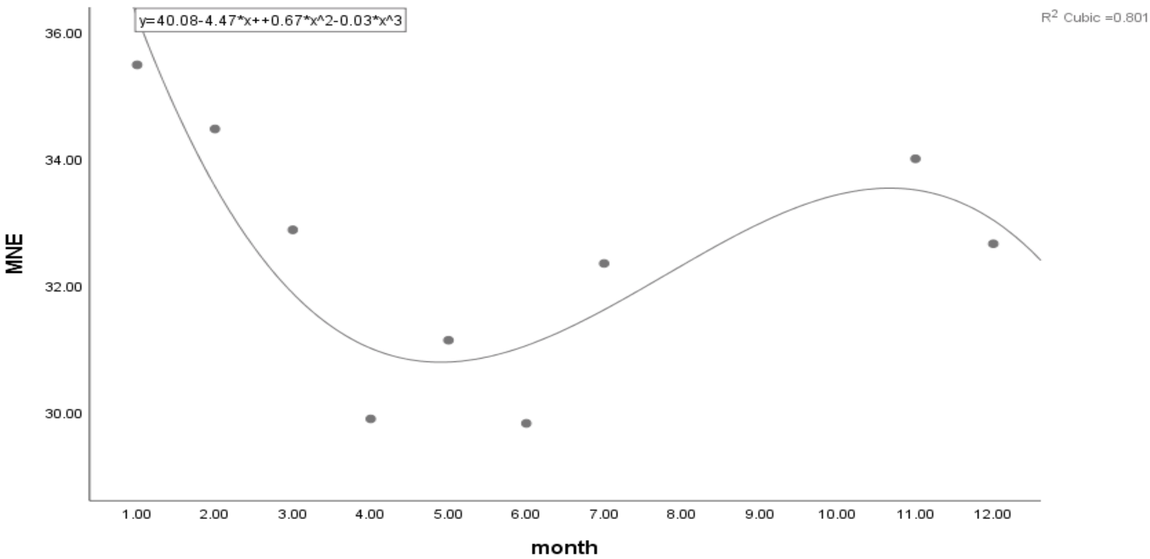

Figure 2. Statistical Relationship of MNE Index and Time for Al-Rusafa Water Treatment Plant.

https://doi.org/10.17993/3ctecno.2023.v12n1e43.176-189

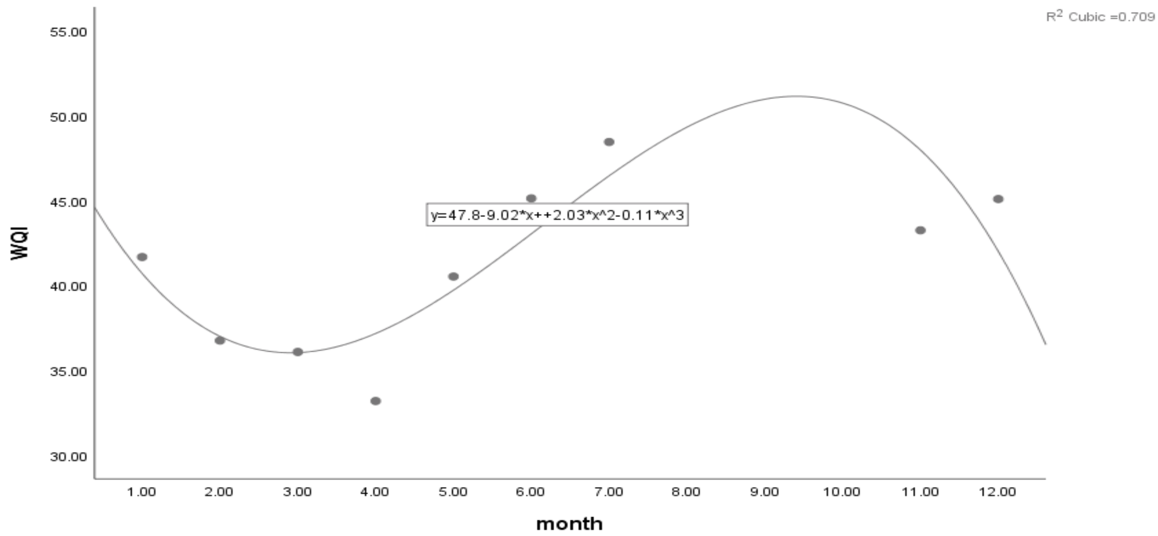

Figure 3. Statistical Relationship of WQI Index and Time for Al-Rusafa Water Treatment Plant.

In which, CCME is,and t is in(month)of all Water Treatment Plant:

$$CCME=0*t+99.99 \tag{4}$$

In which, BCWQI is,and t is in(month)of all Water Treatment Plant:

$$BCWQI=0*t+100 \tag{5}$$

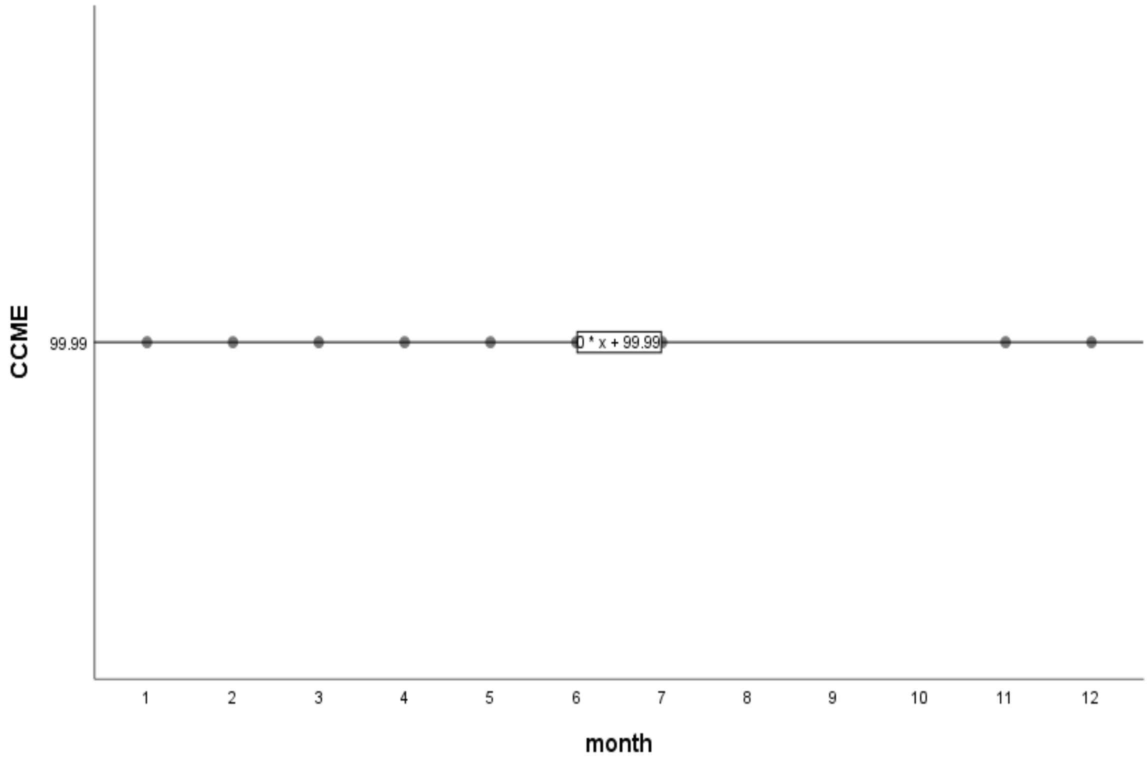

Figure 4. Statistical Relationship of CCME Index and Time for Al-Rusafa Water Treatment Plant

https://doi.org/10.17993/3ctecno.2023.v12n1e43.176-189

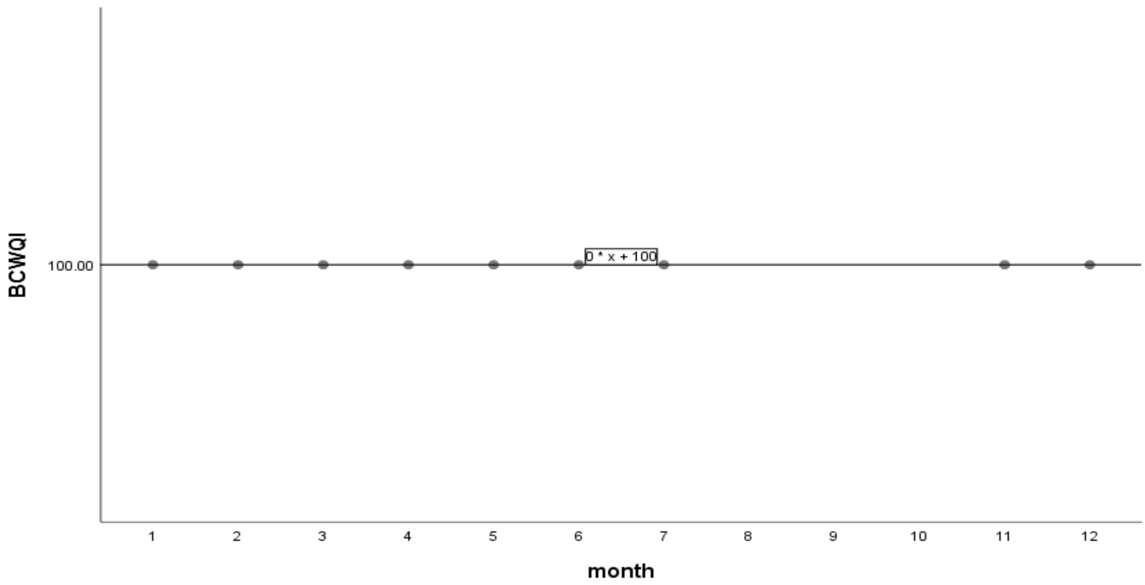

Figure 5. Statistical Relationship of BCWQI Index and Time for Al-Rusafa Water Treatment Plant.

CONCLUSIONS

The results showed that the treated water quality from the water treatment plant studies was good according to the WAV classification. All values of MNE index for treated water from all water treatment plant studied showed that the water is clean but in April, the water quality was very clean according to MNE method classification. All values of WQI for treated water produced from water treatment plant showed that treated water is good water WQI method classification. The results showed that the water quality for treated water was excellent according to the CCME classification. Finally the results showed excellent water quality can be obtained for treated water based on the BCWQI classification.

Table 6. Average monthly test results for treated water produced from Al-Rusafa WTP.(16)

Parameter	unit	Value in test								
		Nov 2021	Dec 2021	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022
Turbidity	NTU	2.8	1.9	1.7	1.1	1.1	0.9	1.5	1.8	2.0
TH	mg·dm-3	312	301	331	325	299	258	257	254	264
PH	-	7.88	7.87	7.81	7.9	7.88	7.87	7.89	7.94	7.98
TDS	mg·dm-3	589	558	585	556	516	456	496	458	471
alk	mg·dm-3	144	141	148	153	152	148	139	139	141
Cl-	mg·dm-3	71	68	73	67	61	53	64	55	62
Mg2+	mg·dm-3	31	29	33	32	28	23	22	23	24
Fe2+	mg·dm-3	0.11	0.04	0.04	0.03	0.05	0.04	0.06	0.05	0.07

https://doi.org/10.17993/3ctecno.2023.v12n1e43.176-189

NO3 -	mg·dm-3	0.42	0.33	0.67	0.43	0.78	0.99	1.16	1.01	1.02
NH3 +	mg·dm-3	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Calcium (Ca^{+2})	mg/L	74	73	78	78	74	66	66	64	66
Sodium (Na^{+})	mg/L	70.6	69.2	80	79	93	102	106	104	131
Sulfate (SO4)	mg/L	195	185	195	188	173	155	168	154	160
EC	µs/cm	879	833	873	830	770	681	741	683	704

Table 7. Water quality indices for Al-Rusafa WTP

WQI	11/2021	12/2021	1/2022	2/2022	3/2022	4/2022	5/2022	6/2022	7/2022
WAV	35.6532	34.1972	36.9857	35.9043	33.6845	30.0593	31.2486	29.9148	31.8064
MNE	0.3400	0.3266	0.3548	0.3447	0.3288	0.2990	0.3114	0.2983	0.3235
wqi	43.246	45.088	41.679	36.753	36.083	33.195	40.525	45.129	48.441
CCME	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
BCWQI	100	100	100	100	100	100	100	100	100

REFERENCES

(1) Bibi, S., Khan, R. L., Nazir, R., Khan, P., Rehman, H. U., Shakir, S. K. and Jan, R. (2016). **Heavy Metals Analysis in Drinking Water of Lakki Marwat District, KPK, Pakistan**. *World Applied Sciences Journal*, 34(1), 15-19.

(2) Khan, N., Hussain, S. T., Saboor, A., Jamila, N. and Kim, K. S. (2019). **Physicochemical Investigation of The Drinking Water Sources from Mardan, Khyber Pakhtunkhwa, Pakistan**. *Life Science Journal*, 16(3).

(3) Pawari, M. J. and Gawande, S. (2015). **Ground Water Pollution & Its Consequence**. *International Journal of Engineering Research and General Science*, 3(4), 773-776

(4) Alrumman, S., Keshk, S. and El Kott, A. (2016). **Water Pollution: Source & Treatment**. *American Journal of Environmental Engineering*, 88-98.

(5) Rafi, M. K., Rmachar, T. and Umamahesh, M. (2011). **A Study on Chemical Analysis of Drinking Water from Some Communities in Nandyal rural areas of Kurnool district, Andhra pradesh, India**. *International Journal of Civil and Structural Engineering*, 2(1), 351.

(6) Ombaka, O., Gichumbi, J. M. and Kibara, D. (2013). **Evaluation of Ground Water and Tap Water Quality in the villages surrounding Chuka town, Kenya**. *Journal of Chemical, Biological and Physical Sciences (JCBPS)*, 3(2), 1551.

(7) Dkhar, E. N., Dkhar, P. S. and Anal, J. M. H. (2014). **Trace Elements Analysis in Drinking Water of Meghalaya by using Graphite Furnace-Atomic**

https://doi.org/10.17993/3ctecno.2023.v12n1e43.176-189

Absorption Spectroscopy and in relation to Environmental and Health Issues. *Journal of Chemistry.*

(8) Hassan, F. M. and Mahmood, A. R. (2018). **Evaluate the Efficiency of Drinking Water Treatment Stations in Baghdad City— Iraq**. *J. Appl. Environ. Microbiol*, 6, 1-9.

(9) Patel, T., Mahour, P. K., Mahour, R., Lautre, H. K. and Shah, P. (2016). **Physico-chemical Analysis of Ground Water Quality of Dhrol**. *Environ Sci Ind J*, 12(12), 127-133.

(10) Gray N. F. (2008). **Drinking Water Quality.** *2nd edition, Cambridge University Press.*

(11) McDuffie B. and Haney J.T. (1973). **A Proposed river pollution index paper presented to American Chem**. *Society, Division of water, Air and waste Engineering*.

(12) Altansukh O. and Davaa G. (2011). **Application of Index Analysis to evaluate the Quality of Tuul River in Mangolia.**

(13) Kalavathy S., SharmaT. R., Sureshkumar P., (2011). **Water Quality Index of River Cauvery in Tiruchirappalli district, Tamilnadu.** *ARCH. ENVIRON. SCI.*, 5, 55-61.

(14) Bharti, N. and D. Katyal. (2011). **Water quality indices used for surface water vulnerability assessment**. *Int. J. Environ. Sci.*, 2(1): 154-173.

(15) POONAM T. (2013). **Estimation of tap water quality in Babylon Governorate/ Iraq**. *International Journal of Advances in Chemistry (IJAC)*. 1(1), 43-45.

(16) **Water treatment plant laboratory in Al-Rusafa, Baghdad Municipality, Baghdad Water Department**.

(17) **The Egyptian Standard for Drinking Water.** No. 108 of 1995.

(18) **Jordanian specification 286 for the year 2008**.

(19) **WHO International Drinking Water Standards 2007 and 2004**.

(20) **Tables comparing drinking water standards in Arab countries with WHO guides (via the internet) for the year 2007**.

(21) **Guidelines for Drinking Water Quality (Second Edition). Part One - Recommendations - About the World Health Organization Global Regional Office for the Middle East (1999)**.

(22) **Enviromental Toxicology & Chemistry**.

(23) **Standarad methods for the examination of water and waste water, edition 20 of 1998**.