Evaluation of Irrigation Water Quality Statusof New Hussainiyah Canal in Karbala City, Iraq

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الخلاصة

تعتبر عملية تقييم نوعية مياه الري واحدة من اهم الامور الواجب مراعتها في ادارة المشاريع الاروائيه لما لذلك من تاثير على الواقع الزراعي والاروائي وكذلك انتاج المحاصيل. في هذا البحث تم تقييم نوعية مياه الري في قناة الحسينيه الجديده من خلال مراقبة اربع محطات على طول القناة ولمدة سنه كاملة خلال العام (2015) وفقا ل(12) متغير لتصبح عدد الاختبارات الكلية (48) اختبار. شملت الفحوصات العناصر: الموصلية الكهربائية، الرقم الهيدروجيني، الاملاح الذائبة الكلية، ايونات الصوديوم، نسبة امتصاص الصوديوم، نسبة ذوبان الصوديوم، الاملاح الكبريتية، ايونات لكالسيوم ، ايونات المغنسيوم، اايونات البوتاسيوم ، ايونات الكلوريدات، والقلوية. تتوزع المحطات المختارة ابتدا من بداية القناة وحتى نهايتها وتمت تسميتها حسب الاتي (الصلامية، الابراهيمية، القنطرة البيضاء والصافي). تم اسخدام الطريقة الكندية لتقييم نوعية مياه الري في القناة وبواقع مؤشر نوعية لكل اربعة اشهر على مدار السنه ولكل محطة. اظهرت النتائج بان مؤشر النوعية لمياه الري في القناة يقع ضمن المستوى المنصف او المقبول لمحطات الصلامية، الابراهيمية، القنطرة البيضاء، في حين كانت بين المستوى المنصف الى القريب من الحد الادنى للمتطلبات في محطة الصافي. وهذا يعني ان نوعية مياه الري في القناة لم تكن تتطابق مع الحدود المرغوب بها خلال بعض اوقات فترة الدراسة. مما تقدم في اعلاه ولاجل المحافظه على هذا المصدر المهم يجب ان تقوم الجهات المكلفة بادارة ملف المياه في محافظة كربلاء بمراقبة نوعية مياه الري وكذلك تقليل منابع التلوث من اجل المحافظه على هذا المصدر المهم .

الكلمات المفتاحية

نوعية مياه الري، قناة الحسينية الجديدة، مؤشر نوعية المياه الكندي، كربلاء، العراق.

Abstract

The assessment of irrigation water quality is a standout amongst the most critical variables that ought to be considered in irrigation projects management, because it has a huge impact on agriculture growth and production. This study has assessed the irrigation water quality status of new Hussainiyah canal in Karbala city, Iraq. Twelve water quality parameters with regard to four observing stations during the year 2015 were surveyed. The 48 samples were tested for, Electric Conductivity, pH value, Total Dissolved Solids, Sodium, Sodium Absorption Ratio, Soluble Sodium Percentage, Sulphate,Calcium, Magnesium, Potassium, Chloride and Alkalinity(EC, PH, TDS, Na, SAR, SSP, SO4, Ca, Mg, K, Cl and Alk). These stations were scattered along the new Hussainiyah canal from upstream to downstream and named as (Salamiyah, Abrahimiyah, QuntaraBedah and Safie). Canadian Water Quality Index (CWQI) technique was applied to make the assessment according to regular time variations(every four months for each station). The results indicated that the irrigation water quality of new hussainiyah canal was in fair conditions for stations, Salamiyah, Abrahimiyah and Quntara Bedah, while it was marginal to fair conditions for Safie station. Also, the conditions of the quality for irrigation water in the canal were not match the eligible levels for some times at the period of study. Regular monitoring for irrigation water quality status and reducing the pollution roots should be adopted from water resources authorities in province of Karbala to pre save that valuable artery source of water.

Keywords

irrigation water quality, new Hussainiyah canal, Canadian Water Quality Index (CWQI), Karbala city, Iraq.

1. Introduction

The status of irrigation water quality, does not get yet the significant priority from water resources authorities in many water sheds area around the world. Absence of data and monitoring about the irrigation water quality in many irrigation projects in Iraq, caused many problems in agriculture productions. This issue might be controlled by comprehension the irrigation water quality data. Water quality index (WQI) is one of simplified tools which converts the complex measurements into easy applicable number. This tool can be used as an effective way to assess the "irrigation water quality" by managers and decision makers of irrigation projects. The main idea of WQI is based on the rule of matching water quality parameters with respect to most commonly standards. Many researchers have been used the WQI to evaluate and monitor the condition of "irrigation water quality". Nabaa Hadi [1], compared the results of applications of the Canadian and Bharagava methods to evaluate irrigation water quality status in Tigris River in Amara region. The results showed that there "was no big difference between two methods and the status of quality of irrigation water was in fair state". Abdulkider [2], assessed water quality of al Husseinieh canal for irrigation purpose in Karbala city using the developed Brazilin model. It was found that "the irrigation water quality was suited to irrigate soils with light texture". Udai Jahad[3], evaluated the water quality index for irrigation in north of Hilla using the Canadian and Bharagava methods. The results of study showed "bad condition of quality at the downstream and nearly al Kifil station". Bashar AL-Sabah [4], evaluated the water quality index of Tigris River for irrigation use in southern of Iraq in Amara city and it was found "the quality of river within permissible limits". Layla Saleh,[5], assessed the irrigation water quality for al Kifil channel by Brazilin model and found "low restriction limit for soils with light texture".The main goal of this research is to evaluate the irrigation water quality of new hussainiyah canal in Karbala city with respect to (12) parameters (EC, PH, TDS, Na, SAR, SSP, SO4, Ca, Mg, K, Cl and Alk) using (CWQI) at main four stations along the canal. The research focused on evaluation the status with respect to the variation in time period for each station. Four months step was adopted to assess the quality of irrigation in the canal along the period of study.

2. Materials and Methods

2.1. Study Area

The study area is located between latitudes (N 36° 00' to 36° 19') and longitudes (E 41° 01' to 42° 85 '), Fig. (1).The new Hussainiyah canal length is about (27) Km lined with concrete and the irrigated area is close to (23) thousand hectares. During the last ten years, the maximum discharge was about (23.63) while the minimum was near (4.2.) Al Musayyib town represents the north border to the canal, while the entrance of Karbala city (Bab Baghdad) is the south border. The main

regulator of the canal is Al-Hindiah barrage with maximum design discharge nearly (50) m3/sec [6] .Generally, the climate is cold and wet in winter, while it is dry in summer. In this study, four stations were selected from upstream to downstream along the canal to assess the irrigation water quality.

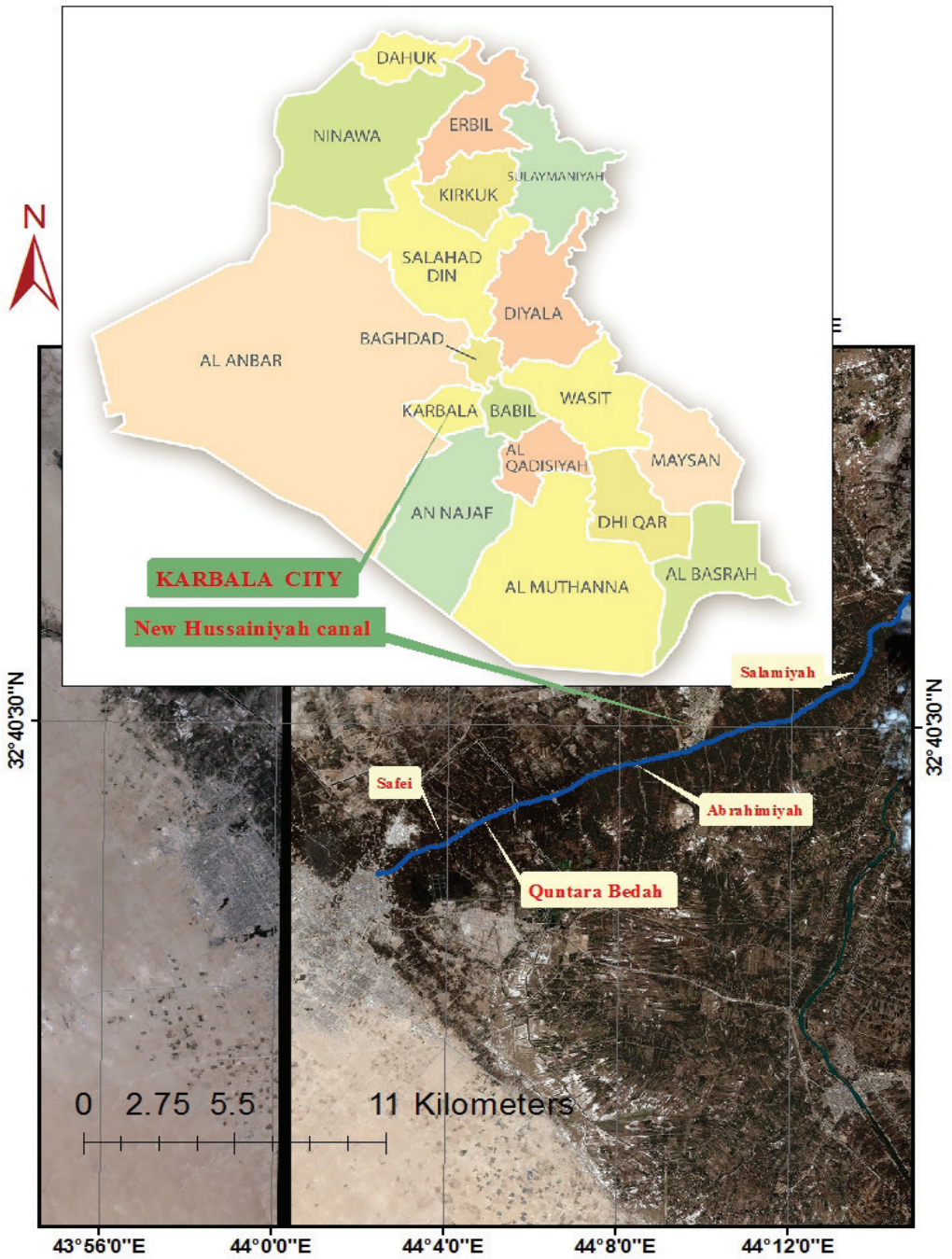

Fig.(1): Location map of the study area

Table (1): Location with respect to latitudes and longitudes for the stations.

ID	Stations	latitudes	longitudes
1	Salamiyah	06 ‘36°18	94 ‘76 42°
2	Abrahimiyah	02 ‘36°14	25 ‘93 41°
3	QuntaraBedah	76‘11 36°	25 ‘31 41°
4	Al-Safie	62 ‘10 36°	51 ‘17 41°

2.2. Testing and Analysis

The (48) water samples were collected from the four monitoring stations along new Hussainiyah canal during the period (January to December 2015). Samples were takenwith cooperation ofwater resources authorities in Karbala city.Polyethylene containers were used to collect the waterfor each stationat the area of study. Samples were analyzed for chemical and physical parameters immediately after collection at the mid-month during the morning. These parameters are (12) parameters (EC, PH, TDS, Na, SAR, SSP, SO4, Ca, Mg, K, Cl and Alk). The standard method for test water was followed to examine the samples,[7].

2.3. Application and Calculation of CWQI

The Canadian Water Quality Index model was adopted to evaluate the irrigation water quality for the area of study. The model considers a standout amongst the most ordinarily utilized procedure to evaluate water quality. The counts of list rely on upon three components with scale from 0 to 100 and need to characterize the variables and the target for water tests. The first factor called the scope (F_1), which represents the rate of variables that don’t coordinate their targets and can be computed utilizing the following equation,[8]:

$$"F_1\left(\frac{Number\ of\ failed\ parameter}{Total\ number\ of\ parameters}\right) *100" \quad \text{.....1}$$

The second component named as recurrence (F_2), which represents the fizzled tests and can be characterized as the rate of individual tests that don’t meet destinations. The recurrence (F_2) can be computed utilizing the following equation, [8]:

$$"F_2\left(\frac{Number\ of\ failed\ tests}{Total\ number\ of\ tests}\right)*100" \quad \text{..... 2}$$

The third element called the abundance (F_3), which can be defined as the degree (outing) to which the fizzled test surpasses the rule.The computations of this component rely on upon three stages, the first and the second represent the excursions and their normalized sum (nse), which can be estimated as the following, [8]:

$$\text{“Excursions} =\left(\frac{failed\ test\ value}{guideline\ value}\right)\text{-1”} \quad \text{..... 3}$$

$$\text{“nse=}\left(\frac{\sum excursion}{Total\ number\ of\ tests}\right)\text{“=} \quad \text{.....4}$$

At the third step can be estimated as fol-

lowing:

$$"F_3=(\frac{nse}{0.01nse+001})" \text{ ..... 5}$$

Finally the CWQI has been calculated according to the following equation:

$$\text{“CWQI= 100-}\sqrt{\frac{F_1{}^2+F_2{}^2+F_3{}^2}{1.732}}\text{,,} \quad \text{..... 6}$$

In general, theCWQIis ranged from 0 to 100. The classification of water quality based on five intervals graduated from poor to excellent. In between values of CWQI represent the intervals marginal, fair and good respectively. Table (2), shows thecategorization ofCWQI, [8].

Table (2): the classification of CWQI,[8 and 9].

Rank	CWQI	Notes
Excellent	95-100	All measurements are within the objectives” “virtually all ofthe time
Good	80-94.9	Conditions rarely depart from natural or de-” “sirable levels
Fair	65.9-79.9	Conditions sometimes depart from natural or” “desirable levels
Marginal	45-64.9	Conditions often depart from natural or desir-” “able levels
Poor	0-44.9	Conditions usually depart from natural or” “desirable levels

In this study CWQI was estimated for the selected stations according to regular time variations during the year 2015 and the evaluation was made every four months for each station. The objectives values that used in the study can be elaborated in Table (3).

Table (3):The objective values that used in estimationCWQI for stations.

Parameters	Unites	Objective Values	References
PH		6.5-8.4	[9] and [10]
Total Dissolved Solids (TDS)	(mg/l)	1225.00	[10] and[11]
Electric Conductivity (EC)	ds /m	1.85	[9]and[10]
Sodium (Na)	(mg/l)	70.00	[10] and[12]
SAR	Percentage value	9.00	[10] and [12]
SSP	Percentage value	40.00	[10]and [12]

Sulphate(SO_4)	(mg/l)	240.00	[12] and[13]
Calcium (Ca^{+2})	(mg/l)	120.00	[13]
Magnesium (Mg^{+2})	(mg/l)	40.00	[13]
Potassium (K^{+})	(mg/l)	10.00	[12]
Chloride (Cl)	(mg/l)	100.00	[10] and [12]
Total alkalinity	(mg/l)	150.00	[12] and[13]

It can be obviously seen from Table (3), the most widely recognized parameters used to evaluate the irrigation water quality according maximum breaking points. This study also, considered the important factors that effect onsodicity hazard and toxicity hazard which can be represented in Sodium Absorption Ratio(SAR) and Soluble SodiumPercentage(SSP).SAR can be defined as,"ratio of the concentration of sodium to the sum of the concentration of calcium and magnesium in water", while (SSP) can be defined as "the ratio of soluble sodium concentration to the total cation concentration",[10]. Generally the high concentration sodium is unfavorable for irrigation water and plant growth, so it's necessary to deal with the restrictions for these remarkable factor. The equations (7 and 8) represent the have been used to calculate the SAR andSSPrespectively as following:

$$SAR=\frac{Na}{\sqrt{\frac{Ca^{+2}+Mg^{+2}}{2}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots 7$$

$$SSP=\frac{Na}{Ca^{+2}+Mg^{+2}+K^{+}+Na} \quad \ldots\ldots\ldots\ldots\ldots\ldots 8$$

Where all the ions should be expressed in meq/L, [10].

3. Results and Discussion

The results of statistical parameters for all stations can be seen in Tables (4 to 7). It is very clear from theses results, that most of parameters are fallen near the objective limits shown in Table (3). With focusing on the other parameters results for all stations, it is obvious that parameters like [Sodium (Na), Sulphate(SO_4),, Calcium (Ca^{+2}), Magnesium(Mg^{+2}) and Chloride (Cl)] are fallen over the suggested targets. The maximum concentration founded for the parameters mentioned above was (127, 348, 128, 44 and 148) mg/l for [Sodium (Na), Sulphate , Calcium (Ca^{+2}), Magnesium(Mg^{+2}) and Chloride (Cl)] in stations Abrahimiyah, Safie, QuntaraBedah respectively. This may reflect the change in irrigation water quality index according to CWQI classification and lead to investigate the status of irrigation quality for that important branch (new Hussainiyah canal). For every four months for each station, the CWQI was estimated. These results can be found in Tables (8 to 10) which contain all effective parameters used to conclude the irrigation water status with respect to selected stations along the canal. By locking through the Table (8), which represents the status con-

cerned from (Jan-Apr), it is clearly seen that the fair status was dominated in all stations. The maximum irrigation water quality index is (72.55) in Salamiyah station, while the minimum is (66.76) with in al Safie station.Table (9), elaborates the status of irrigation water quality in the canal from (May - Aug). From the results shown in the table,the maximum irrigation water quality index is (73.97) in Salamiyah station, while the minimum is (67.10) with in al Abrahimiyah station and the fair status was dominated also. Results shown in Table (10), represent the statusconcerned from (Sep-Dec). The fair condition was obviously seen in stations: Salamiyah, Abrahimiyah and Quntara Bedah. On the other hand side, marginal status was found inal Safie station with minimum CWQI (63.44), while the maximum was found at Abrahimiyah station with CWQI (75.23) and it is very close to results obtained in in Salamiyah station.

These results lead to diagnose that al Salamiyah station was the best station according to classification of CWQI. The variation in station position along the new Hussainiyah canal and time of sampling during the year with respect to different objective parameters may cause the different in irrigation water quality status. When the results obtained have been compared with the results of Abdulkider,[2] and which classified irrigation water quality of the canal as "low to moderate restriction", it can be diagnosed that the result of this research was near to that range concluded by, [2]. But more focusing on the time step of the study and the new selected stations on the canal may give more comprehensive idea about this important index and that what the research tried to do and dealt with it. The application of CWQI on that important canal in Karbala city is very helpful to assess the state of irrigation quality. Also it is very understandable way to decision makers to get their assessment with respect to schedule plan.

Table (4):Summary of statistical parameters of Salamiyah station.

water quality parameters	unit	Mean	Max	Min	St deva
PH		8.04	8.3	7.9	0.14
Total Dissolved Solids (TDS)	(mg/l)	732	844.00	636.00	62.51
Electric Conductivity (EC)	ds /m	1.15	1.30	1.00	0.12
Sodium (Na)	(mg/l)	91.08	114.00	72.00	12.62
SAR		2.05	2.45	1.71	0.24
SSP		34.51	38.00	31.60	2.43
Sulphate(SO_4)	(mg/l)	272.71	341.00	220.00	44.69

Calcium (Ca^{+2})	(mg/l)	86.5	102.00	72.00	10.21
Magnesium (Mg^{+2})	(mg/l)	35.83	39.00	33.00	2.12
Potassium (K^{+})	(mg/l)	4.26	5.10	3.50	0.48
Chloride (Cl)	(mg/l)	116.5	142.00	101.00	11.18
Total alkalinity	(mg/l)	121.92	144.00	104.00	11.62

Table (5):Summary of statistical parameters of Abrahimiyah station.

water quality parameters	unit	Mean	Max	Min	St deva
PH		8.00	8.30	7.70	0.19
Total Dissolved Solids (TDS)	(mg/l)	759.83	922.00	656.00	79.50
Electric Conductivity (EC)	ds /m	1.19	1.34	1.01	0.10
Sodium (Na)	(mg/l)	93.25	127.00	78.00	13.97
SAR		2.09	2.70	1.73	0.28
SSP		34.78	39.70	29.40	2.87
Sulphate(SO_4)	(mg/l)	276.42	334.00	226.00	38.08
Calcium (Ca^{+2})	(mg/l)	89.67	103.00	75.00	11.55
Magnesium(Mg^{+2})	(mg/l)	34.92	40.00	30.00	2.87
Potassium (K^{+})	(mg/l)	4.30	5.40	3.60	0.46
Chloride (Cl)	(mg/l)	119.58	143.00	99.00	12.92
Total alkalinity	(mg/l)	125.08	145.00	112.00	10.53

Table (6):Summary of statistical parameters of QuntaraBedah station.

water quality parameters	**unit**	**Mean**	**Max**	**Min**	**St deva**
PH		8.03	8.20	7.80	0.14
Total Dissolved Solids (TDS)	(mg/l)	713.83	838.00	622.00	73.30
Electric Conductivity (EC)	ds /m	1.13	1.31	1.00	0.12
Sodium (Na)	(mg/l)	88.42	116.00	75.00	12.01
SAR		1.98	2.53	1.74	0.24
SSP		33.54	38.84	30.14	2.45

Sulphate(SO_4)	(mg/l)	266.5	334.00	218.00	38.28
Calcium (Ca^{+2})	(mg/l)	86.83	104.00	72.00	11.18
Magnesium(Mg^{+2})	(mg/l)	36.92	44.00	30.00	3.75
Potassium (K^{+})	(mg/l)	4.18	4.90	3.60	0.44
Chloride (Cl)	(mg/l)	118	148.00	96.00	15.10
Total alkalinity	(mg/l)	124.67	142.00	112.00	10.28

Table (7):Summary of statistical parameters of Al-Safie station.

water quality parameters	unit	Mean	Max	Min	St deva
PH		8.06	8.20	7.80	0.11
Total Dissolved Solids (TDS)	(mg/l)	747.17	882.00	642.00	75.62
Electric Conductivity (EC)	ds /m	1.18	1.38	1.00	0.14
Sodium (Na)	(mg/l)	89.08	112.00	72.00	12.64
SAR		1.97	2.40	1.50	0.28
SSP		32.97	37.86	25.31	3.60
Sulphate(SO_4)	(mg/l)	283	348.00	237.00	41.64
Calcium (Ca^{+2})	(mg/l)	94.08	128.00	77.00	14.89
Magnesium(Mg^{+2})	(mg/l)	35.83	42.00	24.00	4.86
Potassium (K^{+})	(mg/l)	4.23	5.20	3.20	0.63
Chloride (Cl)	(mg/l)	122	142.00	104.00	11.66
Total alkalinity	(mg/l)	125	144.00	108.00	12.55

Table (8): State of irrigation water quality for stations from (Jan-Apr).

Stations **Related factors**	Salamiyah	Abrahimiyah	QuntaraBedah	Al-Safie
F1	25.00	25.00	33.33	33.33
F2	25.00	25.00	27.10	27.10
excursion	3.92	4.50	3.52	4.10

nse	0.08	0.09	0.073	0.09
F3	7.41	8.30	6.80	8.26
WQI (Jan-Apr)	72.55	72.40	66.95	66.76
State of irrigation water quality	Fair	Fair	Fair	Fair

Table (9): State of irrigation water quality for stations from (May - Aug).

Stations **Related factors**	Salamiyah	Abrahimiyah	QuntaraBedah	Al-Safie
F1	25.00	33.33	33.33	25.00
F2	22.92	27.10	22.92	25.00
excursion	2.30	2.64	2.25	2.70
nse	0.05	0.06	0.05	0.06
F3	4.80	5.70	4.76	5.70
WQI (May - Aug)	73.97	67.10	69.10	72.80
State of irrigation water quality	Fair	Fair	Fair	Fair

Table (10): State of irrigation water quality for stations from (Sep-Dec).

Stations **Related factors**	Salamiyah	Abrahimiyah	QuntaraBedah	Al-Safie
F1	25.00	25.00	33.33	41.70
F2	20.83	20.83	22.92	25.00

excursion	1.14	1.10	1.04	1.44
nse	0.02	0.02	0.02	0.03
F3	1.96	1.96	1.96	2.91
WQI (Sep-Dec)	75.22	75.23	69.23	63.44
State of irrigation water quality	Fair	Fair	Fair	Marginal

4. Conclusions:

The overall results of CWQI for stations along new Hussainiyah canal during the period of study, ranked from (63.44 to 75.23). According to these results the quality of irrigation water can be classified as marginal to fair status with clearly domination to fair state.Fair conditions were obtained for stations, Salamiyah, Abrahimiyah and Quntara Bedah, while it was marginal to fair condition for Safie station.These results lead to conclude that the quality of irrigation water was not match the desirable level during some times of the period of study. More efforts should be considered from governorate of Karabala to pre save irrigation water quality with acceptable levels along this important canal. The reduce of pollution sources and monitoring for different control points is very important steps that should be taken from irrigation water authority in Karbala city to keep that valuable source and maintain the agriculture production with in safe level.

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