IRAQI Academic Scientific Journals
Iraqi Journal of Civil Engineering
Available online at https://www.iasj.net/
Journal homepage: https://www.iasj.net/iasj?func=issues&jId=141&uiLanguage=en

# Assessment of Groundwater Quality at Selected Location of three Wells and Al-Warrar Canal, Ramadi City, Iraq.

*Rea'am.Abood*[*1] , *Ayad Mustafa*[2], *Jumaa. Al Somaydaii*[1]

[1] *Department of Dam and water resources Engineering, Engineering College, University of Anbar, Iraq.*

[2] *Civil Engineering Department, College of Engineering, University of Anbar, Iraq.*

A R T I C L E I N F O

*Article history:*
Received 11 /06 / 2021.
Received in revised form 25 /06 / 2021.
Accepted 28 /06 / 2021.
Available online 10 /08 / 2021

Keywords:
Groundwater
Al-Warrar Canal
Irrigation
CCMEWQI
WQI

A B S T R A C T

To assess groundwater quality in Al-Tameem region- Ramadi city west of Iraq, three wells were drilled at a depth of 10m and selected two locations across Al Warrar Canal to represent their water quality. Water samples were collected from these wells and the Warrar Canal to examine water quality. Then results were compared against the World Health Organization (WHO) limits to determine the Water quality index (WQI). It was calculated according to the Canadian Council of Ministers of the Environment (CCME), and the quality of water was evaluated for domestic and irrigation uses. The samples were tested for electrical conductivity, pH, temperature, total dissolved solids, chloride, total hardness, nitrate, and alkalinity according to the standard methods. The results of laboratory analysis showed significant differences among the wells and Warrar Canal water quality in the measured parameters according to WHO limits. Due to many human activities like urbanization, agrarian overflow, drainage of untreated sewage, and industrialization, high values of trace elements and heavy metals were recorded in The three wells. For agriculture purposes, the results show that the water in the three wells is very high salinity, where the Warrar Canal is high salinity, and Canal water causes saline and alkali damages. It was concluded that the WQI in three wells was poor water quality whereas, marginal water quality was pointed in AL Warrar Canal.

DOI: 10.37650/ijce.2021.170714

## 1. Introduction

Groundwater contamination is a dangerous problem that is affecting the quality of water over the world. The multiple sources of water pollution have to lead to higher interest in studying groundwater quality. The development of life results in a rapid increase in pollution because industrial activities and other uses of natural resources lead to high air and water pollution (Al-Saad and Salman, 2003). Toxicity in life and the environment is a result of pollution caused by heavy metals (Sun, et al., 2015). Some metals, such as nitrogen are essential for plants and animals as well (Aktar, et al., 2010). (Dawood, 2018) works on Approach of GIS for Spatial Distribution to analyze the quality of Groundwater at South-West Part of Basrah. The study results showed that some of the parameters were determined beyond the acceptable WHO as well as Iraqi limits. Groundwater can be used for irrigation, drinking, municipalities, and industries.

Ramadi City, especially the study area on the right bank of Al-Warrar canal, suffers from height levels of groundwater. This can be observed when the water level in the canal increase during the flood season.

* *Corresponding author.*
E-mail address: rea19e4001@uoanbar.edu.iq

Therefore, three wells were drilled to 10m in the area on the right bank of Al-Warrar Canal. Samples of water from these wells and Warrar Canal were taken to examine water quality, study, and compare it the (WHO) limits, study WQI according to CCMEWQI, and evaluating it is water quality for domestic and irrigation uses

### *1.1. Study area*

The study area located the area adjacent to the right bank to Al Warrar canal in Al-Ta'meem, between the 33 ° 24' 16 "N to 33 ° 25'15.11" N Latitude and 43 °17'15 "E to 43 ° 18' 0" E longitude between Al Haouz Bridge and Al Qasim Bridge, Figure (1). Moreover, it has an area of about 14 $km^2$ and includes six neighborhoods as well as a complex of apartments, where there are more than five thousand houses.

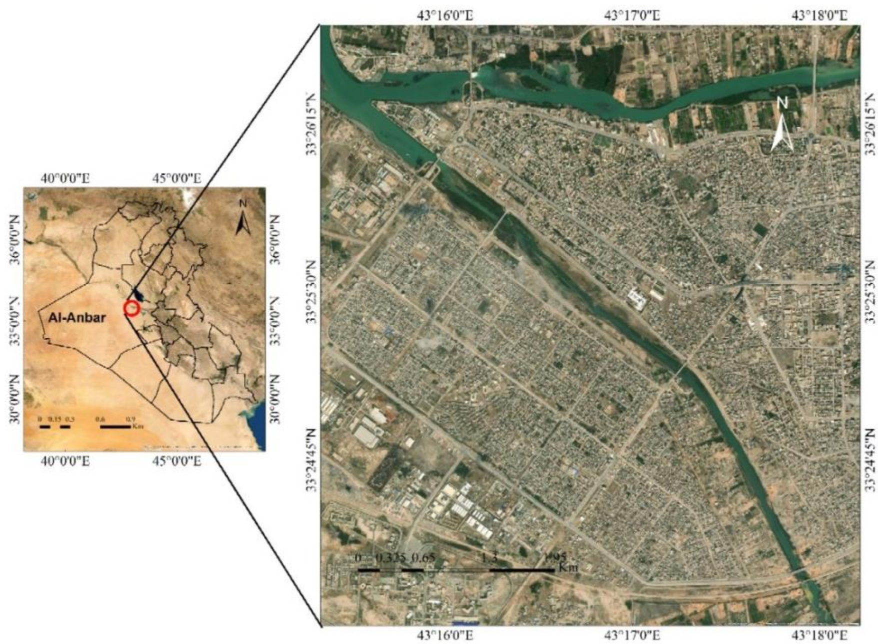


**Fig. 1 The study area for the right bank of Al Warar canal**

### *1.2. Sampling*

Depending on the data of three wells drilled in the right bank to Al Warrar canal in Al-Ta'meem district. 95 water samples of the same depth were collected from five different sites (19 samples each). The sample collection procedure conducted on January/ $1^{st}$ 2021 between 11 and 12 pm. The five sites were distributed as follows: three of these sites are wells that have been drilled, and the other two sites are in the middle and on the canal bank. Sample storage was done by using high-quality plastic bottles tightly closed and kept at 4°C before the test process. These samples tested in the laboratories of the Science College, Fig. 2.

**Fig. 2. Water extraction process from three wells and AL Warrar canal**

## *1.3. Materials*

In this study, physical and chemical water quality parameters were measured. The pH values, temperature, turbidity, and electrical conductivity were determined directly at the study area, while the total dissolved solid concentration was tested in the laboratory. Alkalinity was measured by titration. The Pb, Cr, Cd, Ni, zinc, and copper concentrations, were determined by Atomic Absorption Spectrometry (AAS) method. The methods Association were applied according to (American Public Health Association (APHA), 1995.

The WQI is a widely effective method to specify water quality. It used to determine water convenient for various consumptions. The first method of WQI was presented by Horton (1965). The American Public Health Association suggested the WQI method. Various indices of water quality, which was reviewed by a WQI, is an individual unit less number clarifying the quality of the water. These indices were made by collecting measurements and finding values of the selected water quality parameters. The WQI derivation includes a weight specified for each parameter, standardization of the parameters, normalization of the weights, aggregation of the scores, and calculation of individual WQI scores.

Additional details for CCME WQI are given in CCME. In this study the following equations were used to determine the index values of the CCME WQI standard in the three wells and AL Warrar canal:

$$\boldsymbol{F1 = \left(\frac{(number\ of\ failed\ variables)}{(total\ number\ of\ variables)}\right) x\ 100} \tag{1}$$

The F1 (scope) describes the percentage of variables that do not get their objective at only one time during the period below consideration (failed variables), as a rate to the total number of variables computed.

$$\boldsymbol{F2 = \left(\frac{(number\ of\ failed\ tests)}{(total\ number\ of\ tests)}\right) x\ 100} \tag{2}$$

The F2 (frequency) describes the percentage of the failed tests.
F3 (Amplitude) describes the value by which failed test records do not get their objectives.
F3 is determined in three steps:

1. The summation of times that the concentration of an individual is more than (or less than, when the objective is a minimum) the objective is called an ″ excursion ″ and is described as below. When the value of the test must not be more than the objective:

$$\boldsymbol{excursion\ i = \left(\frac{(failed\ test\ value\ i)}{(objective\ j)}\right) - 1} \tag{3a}$$

For the cases in which that the value of the test must not decrease under the objective:

$$\boldsymbol{excursion\ i = \left(\frac{(\text{objective j})}{(\text{failed test value i})}\right) - 1} \tag{3b}$$

When the objective is zero:

$$\boldsymbol{Excursion_i = failed\ test} \tag{3c}$$

2. The summation when the individual tests are out of compliance is determining by collecting the times of individual tests from their objectives and dividing it by the total number of tests (the values that meet the objective and other values that not meets the objective). This variable that clarified the normalized sum of excursions, or nse , is determined as :

$$\boldsymbol{nes = \frac{\sum_{i=10}^{n} excursion\ i}{No.of\ tests}} \tag{4}$$

3. F3 is determined by using an asymptotic relation that measured the normalized summation of the excursions from objectives (nse) to meet a range between 0 and 100.

$$\boldsymbol{F3 = \left(\frac{nse}{0.01\ nse + 0.01}\right)} \tag{5}$$

The Index of Water Quality (CCME) (CCMEWQI):

$$\boldsymbol{WQI = 100 - \frac{\sqrt{FI^2+F2^2+F3^2}}{1.732}} \tag{6}$$

## 1. Results and discussion

Table 1 shows the results, pH which was recorded in the study area lies within the range of the WHO standards, except for the side of Al-Warrar Canal, which exceeded these limits by recording 8.6. pH clarified acid and alkaline constituents in groundwater and canal water possibly due to carbonates, bicarbonate, and carbon dioxide.

High Turbidity was recorded in all samples, and it was higher than the WHO limits. High turbidity can significantly reduce groundwater quality in the wells and the water canal and can increase the cost of water treatment for domestic and drinking uses.

. High electrical conductivity was recorded in all samples collected from the study area. As shown in Table 2, EC is slightly high (789-13360 μScm), which exceeded the WHO limits.

It has also been found that TDS in the groundwater samples is ranged between (2530 -6550 mg/l), which are higher than the WHO limits. In contrast, the samples were taken from the Canal record slightly low values (390 – 400 mg/l), which is below the limited range.

High nitrate $NO_3$ (11-18) mg/l) was recorded in all samples and was higher than the WHO limits. The aquatic plant growth is subjected to the same influence for Nitrates and phosphates, and thus the same negative effect on the quality of the water (Wahran, 2020).

High sulfate values (259 – 580) mg/l were recorded in the samples for the three wells and the middle location of Al-Warrar canal, which is over the permissible WHO limits. On the other hand, Low sulfate levels were recorded in the sample taken from the canal side(190 mg/l). High sulphate in the water can corrode the transporting pipes. Therefore, plastic pipes are mostly preferable with high sulphate water.

The Total Hardness (T.H) results showed high concentration in all samples collected, it ranged from 730 to 4800 mg/l, that range is over the WHO advisable ranges.

Highly Bicarbonate levels ($HCO_3$ Alk.) were shown for the samples of three wells and the side of the canal ranging between 330 and 396 mg/l, which is over the WHO ranges that specified at 200 mg/l, whereas Bicarbonate levels in the middle of the canal go below these limits be recording 171 mg/l. The primary form of alkalinity is Bicarbonate. The high amounts of bicarbonates and conjunction with calcium can cause the formation of the scale in heating water.

Water temperature of the samples of wells recorded more than the limits of the WHO standards that was set as (20 $C^{\circ}$). At the same time, the samples taken from the canal recorded temperature degrees below the limit of the WHO guideline. Temperature can affect and change the chemical properties of water. The raising in temperature increases the ability of water, especially groundwater to dissolve minerals rapidly from the surrounding rocks and will enhance the electrical conductivity. (Alastal, 2015).

**Table 1. Physicochemical Analysis of Water Samples from Three Wells ($p_1$,$p_2$,$p_3$) and AL Warrar Canal.**

| parameter | $P_1$ | $P_2$ | $P_3$ | Side river | center river | WHO guidelines (Wahran,2020) |
|---|---|---|---|---|---|---|
| pH | 7.95 | 8.1 | 8.1 | 8.6 | 7.5 | 6.5-8.5 |
| Tur (NTU) | 9 | 16 | 14 | 8 | 10 | 5 |
| E.C (µs/cm) | 5170 | 13360 | 10590 | 811 | 789 | 750 |
| TDS (mg/l) | 2530 | 6550 | 5890 | 400 | 390 | 500 |
| $NO_3^-$ (mg/l) | 11 | 16 | 12 | 11 | 18 | 10 |
| $SO_4^{2-}$ (mg/l) | 580 | 500 | 753 | 190 | 259 | 200 |
| T.H (mg/l) | 1320 | 3090 | 4800 | 2120 | 730 | 600 |
| $HCO_3^-$ (mg/l) | 340 | 330 | 339 | 396 | 171 | 200 |
| $Cl^-$ (mg/l) | 99 | 120 | 129 | 132 | 150 | 200 |
| Temp. ($C^{\circ}$) | 23.6 | 21.3 | 21.3 | 13.1 | 13.1 | 20 |

Table 2 shows Water Quality Indices and Table 3 shows the (CCME WQI). By comparing the index for the samples against the WHO Standards, it can be shown that water taken from the wells has low quality and cannot be used for agriculture and domestic use. In contrast, water samples were taken from Al- Warrar Canal showed Marginal water quality.

**Table 2: Water Quality Indices for water samples from Three Wells ($p_1$,$p_2$,$p_3$) and AL Warrar Canal.**

| Sample water Code | Water Quality Index | Status of water quality |
|---|---|---|
| $P_1$ | 26.1123 | Poor water quality |
| $P_2$ | 20.3551 | Poor water quality |
| $P_3$ | 29.342 | Poor water quality |
| Warrar canal (side location) | 55.64 | Marginal water quality |
| Warrar canal (center location) | 57.71 | Marginal water quality |

**Table 3. Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI)**

| The Index for the Quality of Water Canadian Council of Ministers of the Environment (CCME WQI) | |
|---|---|
| 95-100 | Excellent water quality |
| 94-80 | good water quality |
| 60-79 | Fairwater quality |
| 45-59 | Marginal water quality |
| 0-44 | poor water quality |

## *2.1.The Irrigation Water Quality*

Irrigation is classified according to several variables. Table 4 shows the results of heavy metals (mg/L) found in the water samples from the three wells ($p_1$,$p_2$,$p_3$) and AL Warrar Canal (center, side). So far Zinc and Copper showed a low increase in the area of study. The reason for this increase is because the many human activities, such as urbanization, agrarian overflow, drainage of untreated sewage into the river, and industrialization (Wahran, 2020). It also showed the water unsuitable for agriculture in the three wells according to (FAO, 1994).

The comparison of the quality of irrigation water, depending on international classification is classification US Salinity Laboratory, which depends on dissolved solids with the help of electrical conductivity according to Table (5). Electrical conductivity and dissolved solids in wells three were very high, so it was classified as Very High Salinity, and Warrar Canal is High Salinity according to Table (5) (Alabdraba, 2015).

**Table 4: The heavy metals and Trace elements (mg/l) in water samples from the three wells (p1,p2,p3) and AL-Warrar canal (center, side), Ramadi, Iraq.**

| Parameters | P1 | P2 | P3 | Al Warrar side | Al Warrar center | FAO, 1994 |
|---|---|---|---|---|---|---|
| Zn | 0.208 | 0.556 | 0.388 | 0.00 | 0.00 | 2 |
| Ni | 0.391 | 0.612 | 0.565 | 0.202 | 0.133 | 0.2 |
| Cr | 0.03 | 0.08 | 0.02 | 0.02 | 0.02 | 0.10 |
| Pb | 0.244 | 0.507 | 0.530 | 0.148 | 0.00 | 5 |
| $Cd^{2+}$ | 0.052 | 0.110 | 0.091 | 0 | 0 | 0.01 |

**Table (5) US Salinity Laboratory classification of irrigation water** (Alabdraba, 2015)

| Classification | Electrical conductivity EC, (µs/cm) | Dissolved Solids, TDS (mg/l) |
|---|---|---|
| Low salinity | 0-250 | Less than 160 |
| Moderate Salinity | 250-750 | 160-480 |
| High salinity | 750-2250 | 480-1440 |
| Very High Salinity | 2250-5000 | 1440-3200 |

## 2. Conclusions

1- Depending on the results for the index of the water quality in this paper, all water samples registered as water require a pre-treatment before domestic water consumption.
2- This paper discusses the important problem that the water of the wells is not suitable for irrigation purposes because the results data showed that the water in the three wells is very high salinity, especially salt-sensitive crops such as oranges, peaches, beans, lentils, and fallen leaves, which cannot withstand salinity more than 450 ppm.
3- The index of water quality (WQI) should be adopted as a powerful tool for monitoring groundwater quality.
4- The results of the tests showed that the pH was lies within the range adopted by (WHO) standards, except for the right side location of the Al-Warrar Canal. High electrical conductivity was recorded in all water samples.
5- High TDS and $NO_3$ in the samples of the groundwater exceeded the (WHO) limits. Where the sulphate recorded was revealed in the samples for the three wells and Al-Warrar canal and the results showed high recorded for the (HCO3 ) in all three wells and the side location of the canal.

## 3. References


Saod, W. M., Rashid, F. A., Turki, A. M., & Al-Taee, M. J. M. (2019). Water quality indices for Euphrates River. Online Journal of Veterinary Research, 23 (5), 407-413.

Saod, W. M., Al-Heety, E. A. M. S., & Mohammed, M. M. (2020). Spatial and temporal variation of water quality index of Euphrates River in Anbar Governorate, Iraq. AIP Conference Proceedings 2213, https://doi.org/10.1063/5.0000190, Published Online: 25 March 2020.

Khazaal, S. H., Al-Azawi, K. F., Eassa H. A., Khasragih A. H., Alfalawi, W. R. & Al-Gebori, A. M. (2019). Study the level of Some Heavy Metals in Water of Lake Habbaniyah in Al-Anbar-Iraq. Technologies and Materials for Renewable Energy, Environment and Sustainability, TMREES18, 157 (2019), 68–74.

Abdulkareem, A. Z. (2017). Development Models of Artificial Neural Network and Multiple Linear Regression for Predicting Compression Index and Compression Ratio for Soil Compressibility of Ramadi City. Al-Nahrain Journal for Engineering Sciences (NJES). 20(4), 924-936.

El Baba, M., Kayastha, P., Huysmans, M., & De Smedt, F. (2020). Evaluation of the Groundwater Quality Using the Water Quality Index and Geostatistical Analysis in the Dier al-Balah Governorate, Gaza Strip, Palestine. MPDI, 12(262), 1-14.

Dawood, A. S. (2018). GIS Approach for Spatial Distribution Analysis of Groundwater Quality at South-West Part of Basrah. Journal of Engineering, 24(8), 81-95.

Alabdraba, W. M. S., Mohammed, Z. B. Hazaa, M. M., & Resheq A. S. (2015). Evaluation of the Tigris River Water Quality For Domestic and Irrigation Uses Near Drinking Water Treatment Plants Through Baghdad City. International Journal of Management and Applied Science, 1 (9), 63-68.

UNEP, (2007). Global Drinking Water Quality Index Development and Sensitivity Analysis Report.

Rabee, A. M., Hassoon, H. A., & Mohammed, A. J. (2014). Application of CCME Water Quality Index to Assess the Suitability of Water for Protection of Aquatic Life in Al- Radwaniyah-2 Drainage in Baghdad Region. Journal of Al-Nahrain University, 2(17), 137-146.

Jidauna, G. G., Dabi D. D., Saidu, J. B., Abaje, B., & Ndabula, C. (2013). Assessment of Well Water Quality in Selected Location in Jos, Plateau State, Nigeria, International Journal of Marine, Atmospheric & Earth Sciences 1(1), 38-46.

Ugya A. Y., Umar, S. A. & Yusuf A. S. (2015). Assessment of Well Water Quality: A Case Study of Kaduna South Local Government Area, Kaduna State Nigeria. Journal of Environmental Science and Toxicology, 3(3), 039-043.

Canadian Council of Minister of the Environment (CCME), (2001). Canadian Water Quality Guidelines for the Protection of Aquatic Life: CCME Water Quality Index 1.0, Technical Report.

W.H.O. (1996). Guidelines for Drinking Water Quality. (2nd ed. Vol.2).

Ayers, R. S., & Westcot, D. W. (1994). Water quality for agriculture. Food and Agriculture Organization of the United Nations.

Al-Saad, H. T., M. A. R. & Salman, A.N. (2003). Marine pollution, College of Marine Science and environmental, Hodeidah University Press.

Sun, Z., Mou, X., Tong, C., Wang, C., Xie, Z., Song, H., Sun, W. & Lv, Y. (2015). Spatial variations and bioaccumulation of heavy metals in the intertidal zone of the Yellow River estuary, China, Catena 126, 2(20), 43-52.

Aktar, M., Paramasivam, M., Ganguly, M., Purkait, S. & Sengupta, D.( 2010). Assessment and occurrence of various heavy metals in surface water of Ganga river around Kolkata: a study for toxicity and ecological impact. Environ. Monit. Assess. 3 (160), 207–213.

Alastal, K.M., Alagha, J.S., Abuhabib, A.A., & Ababou, R. (2015). Groundwater quality assessment using water quality index (WQI) approach: Gaza Coastal aquifer case study. J. Eng. Res. Tech., 2 (12), 80–86.