



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

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### ARTICLE INFO

#### 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

### ABSTRACT

To classification groundwater quality in the study area, 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 study the Index of Water Quality (WQI). WQI 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 wells three. 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 recommended that the WQI in three wells was poor water quality whereas, marginal water quality was pointed in AL Warrar Canal.

## 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. Therefore, three wells were drilled to 10m in the area on the right bank of Al-Warrar Canal. Samples of water

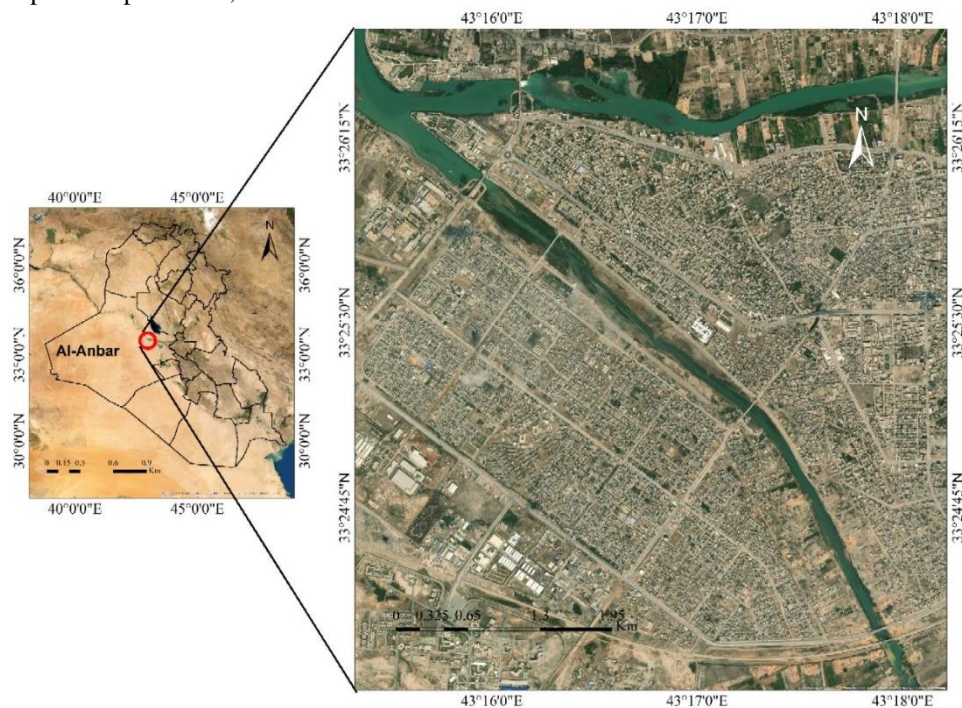
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from these wells and Warrar Canal were taken to examine water quality, study, and compare it the (WHO) limits, study WQI according to CCMEWQI, and evaluating it is water quality for domestic and irrigation uses

### 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  $33^{\circ} 24' 16''$  N to  $33^{\circ} 25' 15.11''$  N Latitude and  $43^{\circ} 17' 15''$  E to  $43^{\circ} 18' 0''$  E longitude between Al Haouz Bridge and Al Qasim Bridge, Figure (1). Moreover, it has an area of about  $14 \text{ km}^2$  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<sup>st</sup> 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  $4^{\circ}\text{C}$  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:

$$F1 = \left( \frac{\text{number of failed variables}}{\text{total number of variables}} \right) \times 100 \quad (1)$$

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.

$$F2 = \left( \frac{\text{number of failed tests}}{\text{total number of tests}} \right) \times 100 \quad (2)$$

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:

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

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

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

When the objective is zero:

$$\text{Excursion } i = \text{failed test} \quad (3c)$$

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 :

$$\text{nse} = \frac{\sum_{i=10}^n \text{excursion } i}{\text{No.of tests}} \quad (4)$$

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.

$$F3 = \left( \frac{\text{nse}}{0.01 \text{ nse} + 0.01} \right) \quad (5)$$

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

$$WQI = 100 - \frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732} \quad (6)$$

## 2. 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  $\mu\text{Scm}$ ), 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  $\text{NO}_3$  (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 ( $\text{HCO}_3$  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 by 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  $^\circ\text{C}$ ). 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<sub>1</sub>,p<sub>2</sub>,p<sub>3</sub>) and AL Warrar Canal.**

parameter	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>	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 ( $\mu\text{s/cm}$ )	5170	13360	10590	811	789	750
TDS (mg/l)	2530	6550	5890	400	390	500
$\text{NO}_3^-$ (mg/l)	11	16	12	11	18	10
$\text{SO}_4^{2-}$ (mg/l)	580	500	753	190	259	200
T.H (mg/l)	1320	3090	4800	2120	730	600
$\text{HCO}_3^-$ (mg/l)	340	330	339	396	171	200
Cl <sup>-</sup> (mg/l)	99	120	129	132	150	200
Temp. ( $^\circ\text{C}$ )	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<sub>1</sub>,p<sub>2</sub>,p<sub>3</sub>) and AL Warrar Canal.**

Sample water Code	Water Quality Index	Status of water quality
P <sub>1</sub>	26.1123	Poor water quality
P <sub>2</sub>	20.3551	Poor water quality
P <sub>3</sub>	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<sub>1</sub>,p<sub>2</sub>,p<sub>3</sub>) 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 (p<sub>1</sub>,p<sub>2</sub>,p<sub>3</sub>) 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 <sup>2+</sup>	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

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### 3. 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  $\text{NO}_3$  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 ( $\text{HCO}_3$ ) in all three wells and the side location of the canal.

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