ASSESSMENT OF SURFACE WATER AND GROUND WATER USING WATER QUALITY INDEX IN, AMERIYAT AL-FALLUJAH AREA, OF CENTER IRAQ

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ABSTRACT

The quality of surface water and groundwater in the Ameriyat Al- Falluja area was assessed using a water quality index. Data of eleven, physico-chemical parameters of three surface water and five groundwater wells were used to calculate the water quality index (WQI). A heterogeneous water quality was reported, most the groundwater samples were unsuitable for drinking and all the surface water samples were suitable for drinking. The values of WQI ranges from 50.6 to 422.2, indicating a suitable to unsuitable water quality.

INTRODUCTION

The suitability for water for drinking is of great importance to the human life, and the impact of water on health derives principally from the consumption of water containing pathogenic organisms or toxic chemicals [17]. The assessment of water quality is important for socio-economic growth and development, where evaluation of water quality for human consumption activities have been given attention especially in developing countries. Water Quality Index (WQI) is one of the most effective tools to express water quality that depicts the composite influence of different water quality parameters and communicates water quality information to the public and legislative decision makers. Water pollution not only affects water quality, but also threatens human health, economic development, and social prosperity [9]. The effects of human activities on water quality are both widespread and varied in the degree to which they the ecosystem and or restrict water use [14]. The concept of WQI to clarify gradation the water quality was first proposed by Horten (1965) [5], where, it is an important technique for evaluating water quality and its suitability water for drinking purposes [13]. WQI reflects composite influence of contributing factors on the water quality for any water system [8], and it represents the grade of water quality in a given water basin. This study is in attempt to assess the water quality in Ameriyat AL-Fallujah area for human consumption using WQI.

The study area

The study area is located in the central part of Iraq, within Anbar Governorate, approximately 40 Km southeast of Baghdad Governorate, between the latitudes (33º 08′ -33º 20′N) and longitudes (43º 40′- 43º56′E) with an area of about 300 km^2 approximately (Figure 1). Euphrates River passes through the city dividing it into two parts; Ameriyat AL-Fallujah and Falluja. The area is bounded from the east by Euphrates River and from the southwest by Karbala Governorate. characterized by with several thousands of villagers who are living around those water since decades, where the main source of water is from the Euphrates River. The study area is part of the Euphrates basin, which is located within the sedimentary plain.

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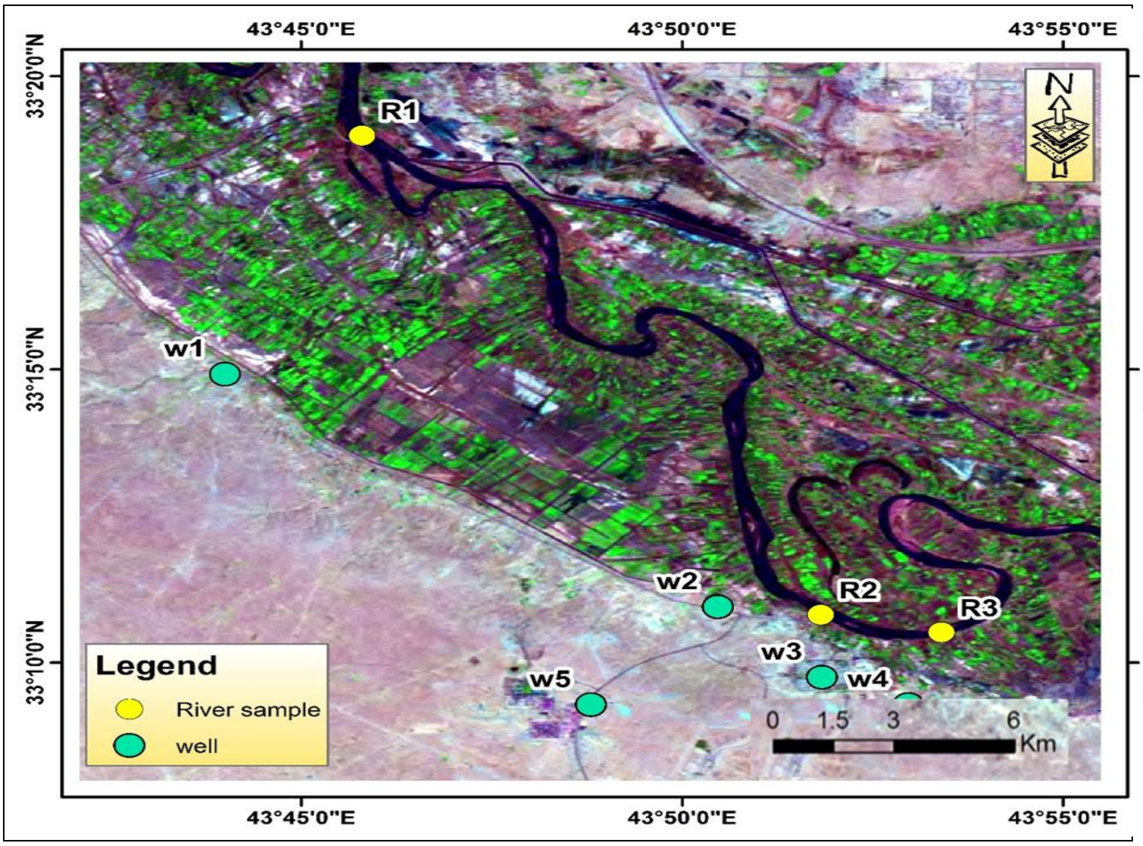

Figure 1: Location map and water sampling sites of the study area

Geological setting

The exposed formations in the study area are shown in Figure 2. Geology plays a role and considered as one of an important factor in determining the quality of Euphrates water and groundwater. The litho stratigraphic section in the study area is known by Injana Formation (Upper Miocene) and Quaternary deposits. Quaternary Deposits are divided into:

(A) Pleistocene deposits

It's a hetrogenous deposits that are formed from fine pebbles consisting of quartz, chert, carbonate and clay. Cement materials mainly are silica and secondary gypsum (1).

(B) Holocene deposits

The Holocene deposits in the study area comprise valley sediments, flood plain deposits and eolian deposits. All these types of deposits form flood plains like Euphrates flood plain near Hit (1).

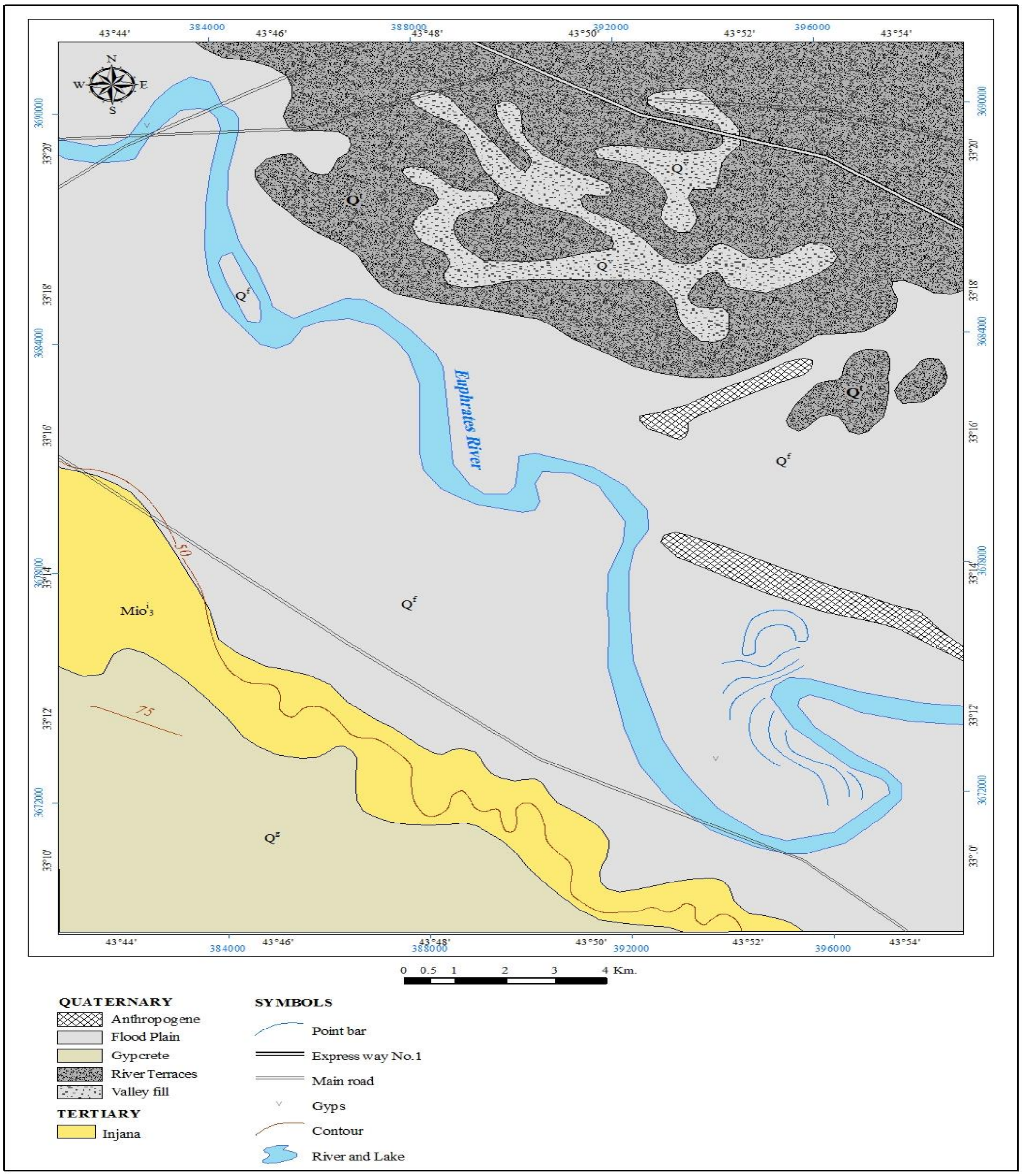

Figure 2: Geological map to the study area.

In terms of geomorphology, the topographic map in study area is show in figure (3). The vast majority of the study area is a flat plain covered by Quaternary deposits.

Some of this land is used as an agricultural field, except to the west border, where the part of the study area is outside of the agricultural land use.

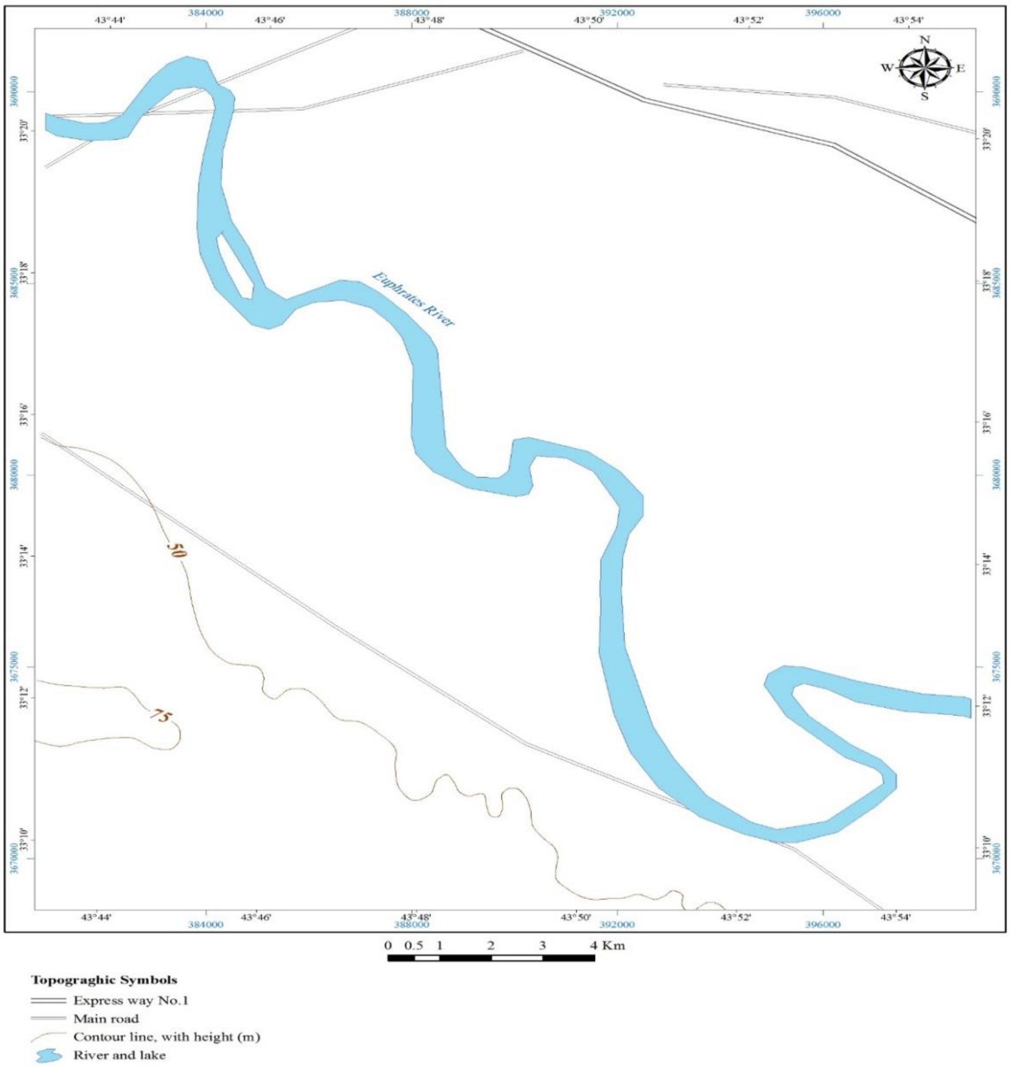

Figure 3: Topography map the study area.

MATERIALS AND METHODS

Surface water and groundwater samples were collected in September 2017, where the sampling sites are shown in figure (1). Groundwater samples were collected after 10 minutes of pumping starting process to ensure of collecting representative samples. The coordinates of each sample (longitude, latitude) are accurately determined using a global positioning system (GPS) instrument (Table 1). Electrical conductivity (EC), the temperature (T^0C) and total dissolved solids (TDS) were immediately measured in situ. All water samples were analyzed for pH, TDS, TH, Ca^{+2}, Na^+, K^+, Mg^{+2}, Cl^-, SO_4^{-2}, HCO_3^-, and NO_3^-, in the laboratory of the Ministry of science and Technology (Table 2). Results of these physico-chemical parameters were mathematically used for the WQI measurements. The calculation of WQI involved 3 stages. In the first stage of the eleven parameters has been assigned a weight (Wi) according to its relative important in the overall quality of water for drinking purposes. The maximum weight of 5 has been assigned to the parameter nitrate due its important in water quality assessment. Magnesium is given the minimum weight (1) which indicates that it may not be deleterious. In the second stage, the relative weight (Wr) was computed from the following equation:

$$Wr = wi / \sum^{n}_{n=1} wi \quad …………. (1)$$

Where, (Wr) is the relative weight, (wi) is the weight of each parameter and (n) is the number of parameters (Table 3).
In the last stage, a quality rating scale (qi) for each parameter is assigned by dividing its concentration in each water sample by its respective standard according to the guidelines of WHO, and then, the result was multiplied by 100 [4]:

$$qi = (C_i - C_0 / S_i - C_0) *100 …………… (2)$$

Where, (q_i) is the quality rating, (C_i) is the concentration of each parameter in each water sample, (C_o) is the ideal value of this parameter in pure water (C_o = 0 except for pH = 7) and (S_i) is the WHO drinking water standard or Iraq drinking water standard for each parameter. For computing the WQI, the SI is first determined for each parameter, which is then used to determine the WQI as indicated by the following equations [11]:

$$SI_i = Wr * qi …………. (3)$$
$$WQI = \sum_{i=1}^{n} SIi………...(4)$$

Where, (SI_i) is the sub-index of *i*th parameter, (q_i) is the rating based on concentration of *i*th parameter and (*n*) is the number of parameters (Table 3).

Table 1: Coordinates of surface water and ground water sampling sites

Symbol	Latitude	Longitude	Well depth(m)	Name location
W1	33 14` 55.1``	43 44` 0.72``	40	Ameriyat AL-Falluja
W2	33 10` 57.3``	43 50` 28.7``	30	Ameriyat AL-Falluja
W3	33 09` 45.8``	43 51` 50.8``	30	Ameriyat AL-Falluja
W4	33 09` 17.9``	43 52` 58.5``	30	Ameriyat AL-Falluja
W5	33 09` 17.4``	43 48` 48.5``	21	Ameriyat AL-Falluja
R1	33 18` 59.1``	43 45` 48.4``	-	Ameriyat AL-Falluja
R2	33 10` 49.1``	43 51` 49.6``	-	Ameriyat AL-Falluja
R3	33 10` 31.5``	43 53` 24.3``	-	Ameriyat AL-Falluja

Table 2: Physico-Chemical Parameters (mg/l) and the computed WQI for each sample

NO.	TDS	PH	TH	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Cl^{-}	SO_4^{-2}	HCO_3^{-}	NO_3^{-}	WQI
R1	630	7.8	361.1	82	38	52	1.4	97	193	162	1.7	50.6
R1	630	7.8	361.1	82	38	52	1.4	97	193	162	1.8	50.6
R3	645	7.8	374.4	84	40	55	1.7	99	196	165	1.8	51.8
W1	5410	7.9	2867.8	769	230	690	12	1453	1698	545	2	369.1
W2	6170	7.8	3272.7	834	289	780	18	1690	1878	667	2.4	422.2
W3	4640	7.9	2333.7	654	170	612	11	1034	1654	490	2.5	316.3
W4	5455	7.9	2896.7	774	234	702	13	1469	1700	550	2.1	372.6
W5	4165	7.2	1999.5	545	155	580	10	980	1456	430	2.1	276.6

Table 3: Iraqi standards, Weight and Relative weight for each parameter (Ramakrishnalah et al, 2009)

Chemical parameter (mg/l)	*Si* (Iraqi standard) (2009)	(WHO Standard) (2008)	Weight (*wi*)	Relative weight (*Wr*)
pH	6.5-8.5	7-8	4	0.1212
TDS	1000	1000	4	0.1212
TH	500	100-500	2	0.0606
$Ca2^{+}$	100	75-200	2	0.0606
Mg^{2+}	50	30-150	2	0.0606
Na^{+}	200	200	2	0.0606
K^{+}		12	2	0.0606
Cl^{-}	250	250	3	0.0909
SO_4^{2-}	250	250	4	0.1212
HCO_3^{-}	-	200	3	0.0909
NO_3^{-}	50	50	5	0.1515
Total			∑wi= 33	∑ = 0.99

RESULTS AND DISCUSSION

The individual and statistical physio-chemical parameters along with computed WQI are list in Table 2. The mean value of pH is slightly alkaline (7.8) in surface water and (7.7) in groundwater. TDS refers to types of minerals present in water equivalent to a mean value of 635 mg/l in surface water and 5213 mg/l in groundwater. The mean value of TDS in groundwater is higher than that recommended by WHO. From the results of cations Ca^{2+} (82 mg/l), Mg^{2+} (38 mg/l), Na^{+}(53 mg/l) and K^{+} (1.5mg/l), where the anions SO_4^{-2} (194mg/l), Cl^{-} (97 mg/l), HCO_3^{-} (163 mg/l) and NO_3^{-} (1.63mg/l) in surface water . In groundwater, Ca^{2+} (715 mg/l), Mg^{2+} (215 mg/l), Na^{+}(672 mg/l) and K^{+} (12.8mg/l) and anions SO_4^{-2} (1677mg/l), Cl^{-} (1325 mg/l), HCO_3^{-} (2682 mg/l) and NO_3^{-} (2.22mg/l). It is clear that all the parameters are less than the WHO recommended limits (2008) in surface water and all parameters are higher than the WHO recommended limits (2008) in groundwater with the exception of Mg^{2+} and NO_3^{-} being below of WHO recommended limits. The abundance of cations are ordered as $Ca^{2+} > Na^{+} > Mg^{2+} > K^{+}$, with anions as $SO_4^{-2} > Cl^{-} > HCO_3^{-} > NO_3^{-}$. The computed WQI varied from 50.6 to 422.2 (Table 2). The WQI standard classification stated by Ramakrishnalah et al. (2009) [10] presented in Table 4 was used to outlook the water quality. According to the chemical and physical parameters that listed in Table (4), consequently, has been used to outlook the water quality of the groundwater and surface water samples; groundwater has a wide range of WQI ranged from (276.6 - 422.2), therefore; WQI considered varied from very poor water (W5), to unsuitable quality (W1, W2, W3, and W4) because of the high values of WQI values computed. They are good quality in surface water samples (R1, R2 and R3).

Table 4: Water quality classification according to the WQI values (Ramakrishnalah et al, 2009).

WQI value	class	Water quality	Sample No.
≤50	I	Excellent	
50-100	II	Good water	R1 , R2 , R3
100- 200	III	Poor water	
200- 300	IV	Very poor water	W5
≥ 300	V	Un suitable water	W1 , W2 , W3 , W4

Surface water samples (R1, R2 and R3) that have WQI values of 50.6, 50.6 and 51.8 respectively are good water, due to the dilution processes by water coming from the river. Therefore, it is permissible for human consumption in terms of chemical composition. Wells (W5) have WQI values of 276.6 which is very poor water. Finally, Wells W1, W2, W3 and W4 that have WQI values 369.1, 422.2, 316.3 and 372.6 respectively have unsuitable water quality. Additional concentration of ions was originally derived by dissolving minerals due to percolation of water through soil and by anthropogenic activity which is considered as a major source of groundwater deterioration. According to the WHO (1993) [15] and Davis and De west (1966) [2], drinking water should not contain sodium in amounts exceeding 200 ppm. Sodium ion in groundwater raised due to the effect of irrigation projects which move static level of groundwater up to dissolving salts in the capillary zone. The reason for the deterioration of groundwater quality is a substantial increase in the sodium, chloride and sulfates. The sources of nitrate are the leachate of crop nutrients and nitrate fertilizers that used by farmers in the study area.

CONCLUSIONS

The WQI reflected the water quality in surface water and groundwater. Five groundwater wells and three surface water distributed in an area of 300 km^2 are characterized by heterogeneity of water chemical composition due to the run off influences. Running water on the surface is directly recharged the underneath aquifer. Surface water are classified as good category, whereas, groundwater are classified as very poor water and unsuitable water. Negative impact on groundwater quality was detected due to the effect of irrigation projects which raised the static water level leading to increase salinity and the reason for the deterioration of groundwater quality is a substantial increase in the sodium, chloride and sulfates. The sources of nitrate are the leachate of crop nutrients and nitrate fertilizers that used by farmers in the study area. All of the groundwater samples are unsuitable for human drinking.

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تقويم المياه السطحية والمياه الجوفية باستخدام مؤشر جودة المياه في منطقة عامرية الفلوجة وسط العراق

علي محمد الدليمي أيسر محمد الشماع

الملخص

تم تقويم نوعية المياه السطحية والجوفية في منطقة عامرية الفلوجة باستخدام مؤشر جودة المياه. استخدمت بيانات أحد عشر من المعلمات الفيزيائية–الكيميائية لثلاث عينات من المياه السطحية ولخمس عينات من المياه الجوفية لحساب مؤشر جودة المياه. تم الحصول على نوعية مياه غير متجانسة، إذ كانت عينات المياه الجوفية جميعها غير صالحة للشرب بينما كانت عينات المياه السطحية كافة صالحة للشرب. تتراوح قيم **WQI** من **50.6** إلى **422.2**، مما يشير إلى وجود مياه صالحة للشرب ووجود مياه غير صالحة للشرب.

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