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Application of GIS Technique to Assess the Habbaniya Lake Water for Human Consumption

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ABSTRACT

Geographic Information System (GIS) technique was used in this study to produce a Water
water of Habbaniya Lake for drinking purposes. Sixteen samples of fresh surface water we
physiochemical parameters of the WQI. These parameters include Total Dissolved Solid
Potassium, Chloride, Sulfate, and Nitrates. The result of these parameters has been transfe
water quality database and map of spatial distribution for each parameter using the inverse
results of these parameters were also used to calculate irrigation water quality index values,
the production of the water quality index map. The spatial distribution index of drinking w
this map. It shows that WQI for all water samples is within the second category (50-100)
category (<50). The short-scope of WQI indicates that the water quality of Habbaniya La
water quality that fluctuated from excellent water to good water for human drinking. It sh
Habbaniya Lake waters is more appropriate for drinking since the Al-Warar Canal drains in

1. Introduction

Euphrates and Tigris rivers and their tributaries are the main and important sources of fresh surface water in addition to the lakes, and just a little of water resources (14%) originates from groundwater [1]. Habbaniya Lake is one of the largest surface water bodies in the Anbar governorate and one of the most important freshwater resources for the people living in its vicinity. The capacity of Lake Habbaniya can help reduce the impact of droughts and floods by reserving huge quantities of water and using it as a source of water for drinking, industry, and a water system for agriculture.

Biological and Environmental studies have been studied by a large number of researchers to investigate the properties of Habbaniya lake [2]; [3]; [4]; [5]; [6]. The major impacts on the lakes' ecosystem are building a dam, climate change land-use change, and pollution, these factors can affect to a varying degree. Atmosphere assumes a significant job in impacting the connection among precipitation and evaporation that add to increment or reduction of water in the region along these lines its quality changes [7].

The description of the occurrence of distinct elements and their relationship to the surrounding material is part of the study of water quality as well as the different environments, land use land covers hydrologic conditions, and human activity [8]; [9]. One of the most useful instruments is the water quality index, which is used in many countries in evaluating water quality [10]; [11]. The WQI is a route for consolidating the perplexing water quality information into a solitary proclamation or single worth [12].

In the current study, 16 surface water samples within Habbaniya Lake were collected for evaluation in terms of quality and validity using the WQI technique based on GIS. This strategy has seen a lot of success in recent years, and it's a great way to get a thorough picture of the health of the surface water by combining composite data. Numerous investigations have confirmed the significance of WQI as an indicator to evaluate water quality as suggested for the first proposed time by [13]. Scientists built up the norm's charts for drinking water at the Salinity Laboratory of the US [14]; [15].

The study of WQI has been increased recently in many countries and found to be a simple tool in evaluating the composite of water [16]; [17]; [18]; [19]; [20]. The main objective of this study is to assess the Habbaniya Lake water

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suitability for human consumption based on the WQI map created with a tool of the ArcGIS Spatial Analyst.

1.1. Study Area

Habbaniya Lake is situated in Anbar Governorate to the south of Ramadi city, adjacent to the village of Al-Angoor. This lake is fed by the Euphrates River and has 2 water outlets which are the Majara canal and the Theban canal [21]. Geographically the Habbaniya Lake is located between longitudes of 43˚19′40.6″- 43˚36′34.4″ E and latitudes of 33˚10′37.7″ –33˚22′20.8″ N occupies about 364 km^2, with a mean elevation of 44m above sea level Figure 1.

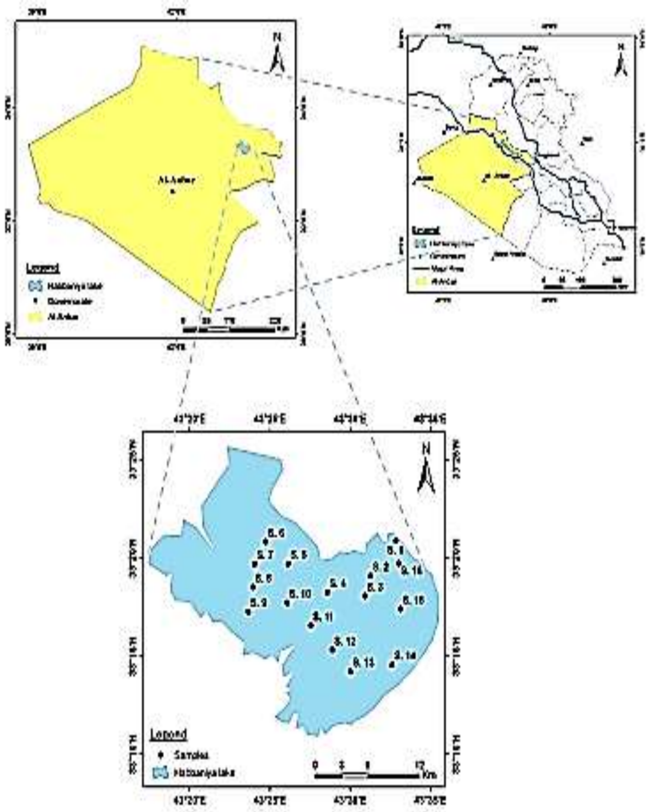

Fig. 1: Study area and selected stations

Geologically, the area around Lake is characterized by exposed many formations; involve Early Miocene is the Euphrates, Middle Miocene are Nfayil and Fatha, and Late Miocene is Anjana as well as Quaternary sediments [22].

2. Materials and Methods

2.1. Data Collection

Sixteen Surface water samples were collected in a random manner in polyethylene bottles based on a preliminary field study conducted in various places of Habbaniya Lake, during the month of October 2019 (Figure 1). Chemical parameters pH, TDS, Calcium, Magnesium, Sodium, Potassium, Chloride, Sulfate, and Nitrate ions have been utilized for the appraisal of water suitable for human consumption to develop the WQI technique. The World Health Organization Standard [23] for drinking purposes was utilized to calculate the WQI model.

2.2. Calculation of WQI

The calculation of the WQI model includes several steps: First, unit weights are assigned to the chemical parameters depending on their relative significance in the general nature of water quality for human uses and their crucial function in the quality of water for drinking purposes. Assigned Weights in the WQI technology classified water quality depending on purity degree using the most common parameters to determine water quality [24].

To calculate the unit weight of the WQI parameters, the following equation was used:

$$\mathbf{Wi=K/Si}$$

Where: **Si**: is the suggested standard estimation of each parameter. **K** is the proportionality constant. Where it's determined by utilizing the following formula:

$$\mathbf{K=1.0/\{\sum (1.0 / Si)\}}$$

In the subsequent advance (second step), each parameter is assigned a scale of a quality rating (qi) by means of division concentrations of water samples by its particular suggested standard value, and then the result is multiplied by a hundred [25]; [26]:

$$\mathbf{qi = \{(X_i - X_0)/ (S_i - X_0)\} *100}$$

Where; the quality rating is represented by **qi** in the above equation; the chemical parameter concentrations of water sample are represented by $\mathbf{X_i}$ in mg/l except Hydrogen Number without unity; while the $\mathbf{X_0}$ is the parameter's optimum value in pure water ($X_0 = 0.0$ except for pH =7.0).

For computing WQI, the index of parameters (**SIi**) is determined first which in turn is used in the calculation of the WQI as the equation that follows:

$$SI_i = Wi * qi$$

$$HWQI = \sum_{i=1}^{n} SI_i$$

The statistical physic-chemical parameters, as well as the WQI calculated, are listed in Table 1. Table 2 shows the weighted arithmetic and standard values for each parameter.

Table 1: Physical-chemical properties of water samples are summarized statistically and the computed WQI for each sample.

Sample No.	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Cl^{-}	SO_4^{-2}	NO_3^{-}	pH	TDS	WQI
S. 1	85.5	46.3	93	7.1	185.0	248.1	3.0	8.5	726.4	80.35
S. 2	70.5	40.6	71	6.3	142.6	235.8	3.1	8.3	630.7	72.02
S. 3	72.0	44.9	91	7.0	172.7	271.0	4.0	8.4	725.5	76.68
S. 4	72.5	46.7	88	6.9	163.0	278.2	3.5	8.4	740.3	76.23
S. 5	60.5	31.5	52	6.0	112.0	179.0	5.0	7.6	532.2	49.67
S. 6	55.0	30.2	47	3.8	97.0	158.0	4.2	8.2	455.2	56.49
S. 7	59.3	34.0	48	8.6	102.0	163.0	3.4	7.8	489.7	63.59
S. 8	62.3	32.5	52	4.8	103.0	178.2	6.0	7.8	502.9	49.11
S. 9	61.5	33.5	52	4.5	105.0	173.2	6.2	7.9	499.1	51.19
S. 10	73.5	36.0	72	6.9	139.0	209.9	5.6	7.8	612.4	59.53
S. 11	71.4	43.9	87	7.0	155.2	250.2	4.5	8.1	675.2	69.71
S. 12	73.5	46.6	100	7.3	160.4	280.6	3.2	8.4	745.8	77.75
S. 13	74.1	51.3	107	7.5	176.5	297.1	3.3	8.4	811.7	81.61
S. 14	75.0	51.9	112	7.7	178.5	304.9	4.9	8.5	780.6	84.70
S. 15	72.9	47.9	103	7.1	172.7	291.3	5.0	8.4	746.6	78.97
S 16	74.3	45.3	102	7.1	166.8	289.3	2.3	8.5	733.7	79.91
Ave.	69.6	41.5	79.8	6.6	145.7	238.0	4.2	8.2	650.5	
All parameters are in mg/ l except pH without unit										

Table 2: Weighted arithmetic and standard values for each parameter according to [23]

Parameters	Units	Standard (Si) [23]	1/Si	K.	Weight (Wi)
pH	-	6.5-8.5	0.1176		0.413
TDS	mg/ l	1000	0.001		0.003
Ca^{2+}	mg/ l	75	0.013		0.046
Mg^{2+}	mg/ l	50	0.02		0.07
Na^{+}	mg/ l	200	0.005	3.5137	0.017
K^{+}	mg/ l	10	0.1		0.35
Cl^{-}	mg/ l	250	0.004		0.014
SO_4^{2-}	mg/ l	250	0.004		0.014
NO_3^{-}	mg/ l	50	0.02		0.07
Total			$\Sigma 1/Si=$ 0.2846		1

3. Results and Discussion

3.1. Correlation Matrix Analysis (CMA)

The CMA of numerous variables is a very valuable tool for improving research and advancing science to new heights [27]. The results of the correlation matrix analysis of the WQI and its parameters in Habbaniya Lake are listed in Table 3.

The analysis' correlation determines the degree of convergence in the link between the chemical variables. The best linear correlation between the 2 chemical variables is shown by the correlation coefficient with a value that is closer to +1.0 or -1.0. The purpose of this method's analysis is to determine the nature of the relationship between the determinants of drinking water chemical parameters and the WQI. There is a strong correlation between water parameters except for NO_3^- attributed mainly to the exposed rocks and sediments in the recharge area. The main sources of NO_3^- may incorporate overflow or drainage from prepared agrarian terrains, industrial and municipal wastewater, feedlots of animals, urban drainage, dumps of refuse, and decaying plant within the River basin of recharge area. As well as agriculture activities which distribute mainly along the northwestern part of the lake.

Table 3: Water quality parameters and WQI relationship in the concept of a correlation coefficient.

	WQI.	pH.	TDS.	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	SO_4^{2-}	NO_3^{-}
WQI.	1									
pH.	.917	1								
TDS.	.920	.811	1							
Ca^{2+}	.796	.676	.859	1						
Mg^{2+}	.950	.850	.977	.821	1					
Na^{+}	.923	.831	.981	.838	.973	1				
K^{+}	.691	.355	.634	.573	.645	.606	1			
Cl^{-}	.923	.825	.974	.922	.952	.960	.617	1		
SO_4^{2-}	.918	.836	.983	.795	.972	.982	.589	.945	1	
NO_3^{-}	.651-	.625	.461	.408-	.457-	.420-	.494-	.464-	.441-	1

3.2. GIS database generation for water quality

The water samples were chemically analyzed, and the results for the chemical components are presented in Table 1. These results were used to generate a water quality database for the research area using a GIS environment. Each parameter's spatial distribution map (SDM) has been created with the help of the spatial analyst extension, and IDW modeling techniques as shown in Figures (2 to 10).

The TDS values in the Habbaniya Lake waters are within a range of 455 to 811 mg/l (Figure 2). The TDS levels clearly increase in the southeastern direction and all the water samples do not exceed the Iraqi standard for drinking water. Water samples in the research area had pH values ranging from 7.6 to 8.5 (Figure 3) indicating that the groundwater is alkaline.

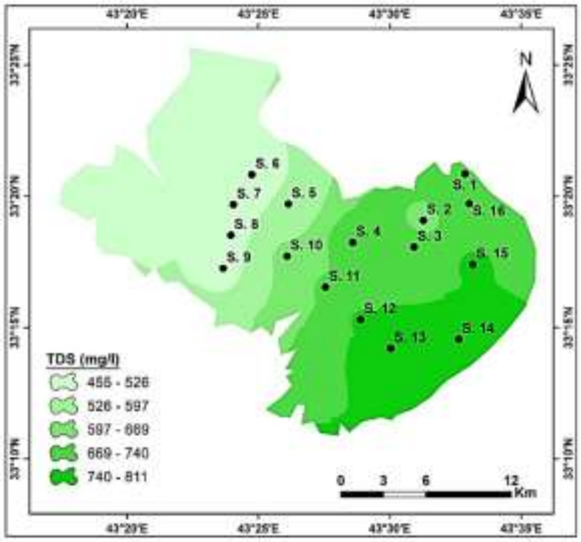

Fig. 2: Distribution of TDS in Habbaniya Lake

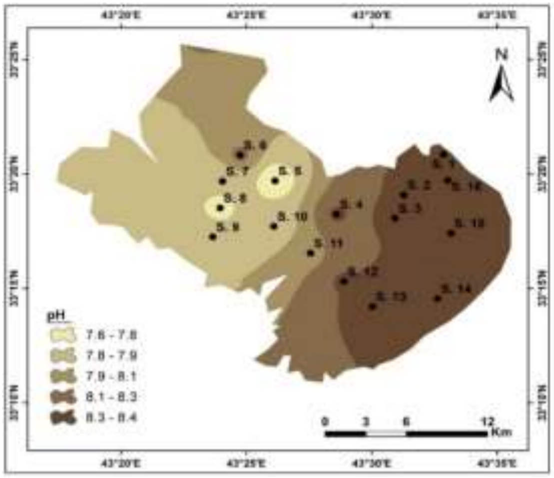

Fig. 3: Distribution of pH in Habbaniya Lake

A spatial distribution map of Ca^{2+} and Magnesium (Mg^{2+}) ions has been prepared as shown in Figures (4 and 5). It has been observed that only 6% of the $Ca^{2+}$and 12% of Mg^{2+} exceed the WHO limits.

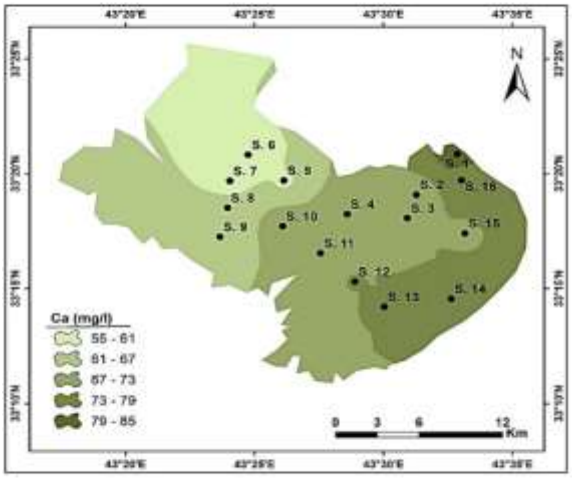

Fig. 4: Distribution of Ca^{2+} in Habbaniya Lake

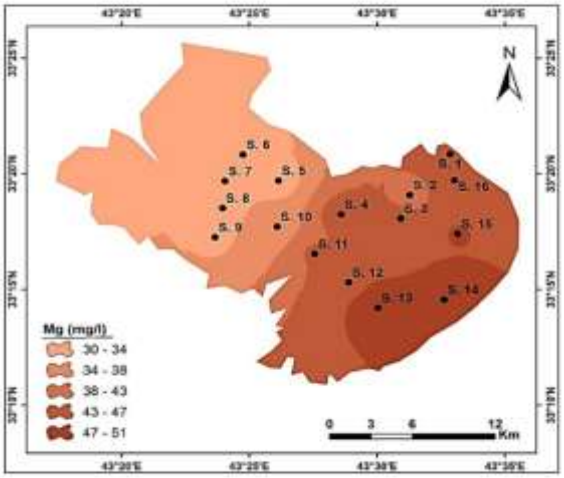

Fig. 5: Distribution of Mg^{2+} in Habbaniya Lake

Potassium (K^+) concentrations are found in the studied area within WHO's allowed limits as shown in (Figure 6). The sodium ion is commonly found in large concentrations in water because it is present in most rocks and soils and is easy to dissolve. According to [23], the maximum permitted value for sodium-ion is 200.0 mg/l. Hence all of the water samples in Habbaniya Lake are within WHO's allowed limits (Figure 7). Chloride contents in Habbaniya Lake are within WHO's allowed limits (Figure 8).

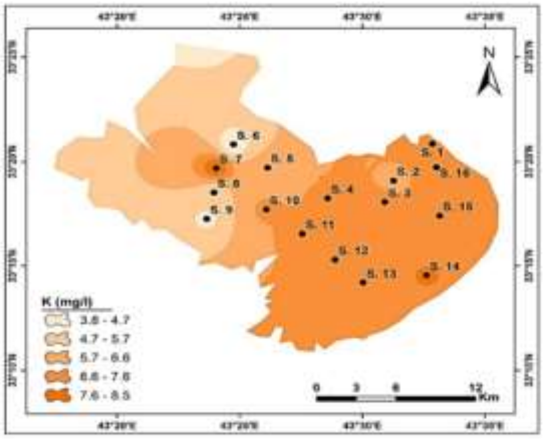

Fig. 6: Distribution of K^+ in Habbaniya Lake

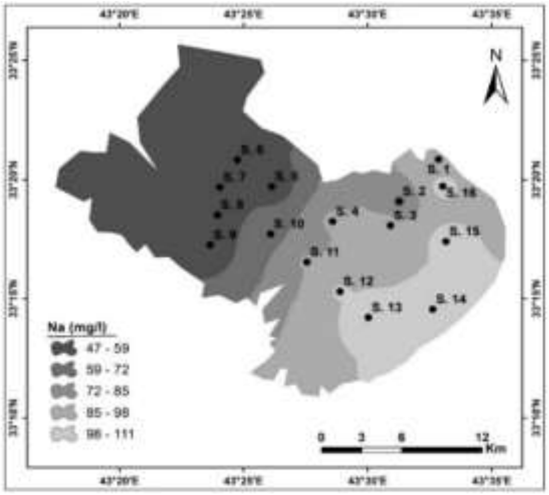

Fig. 7: Distribution of Mg^{2+} in Habbaniya Lake

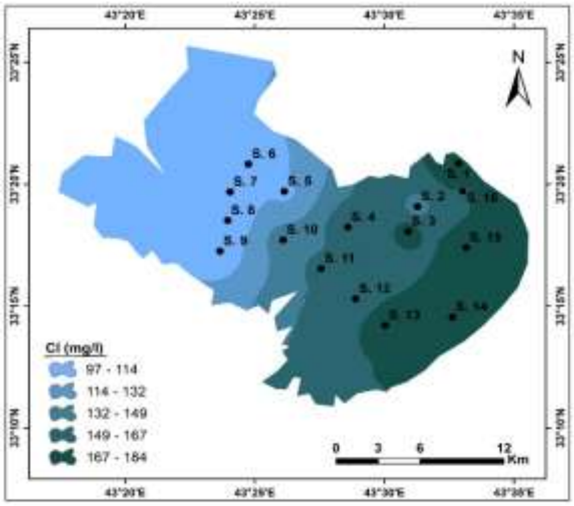

Fig. 8: Distribution of Cl^- in Habbaniya Lake

Sulphate contents in Habbaniya Lake ranged from 158 to 304.9 mg/l (Figure 9). Consequently, 50% of the water samples exceed the permissible limits of [23] water standards. The values of Nitrate (NO_3^-) vary from 2.3 to 6.2 mg/l in water samples (Figure 10).

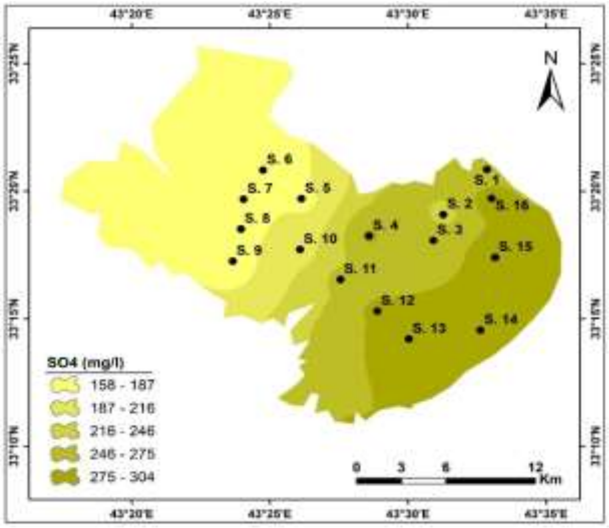

Fig. 9: Distribution of SO_4^{-2} in Habbaniya Lake

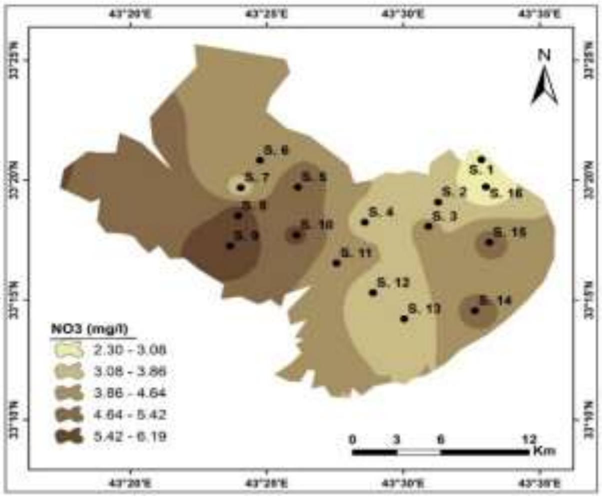

Fig. 10: Distribution of NO_3^- in Habbaniya Lake

3.3. Generation of WQI map

The computed WQI values are divided into five categories; according to [28] (Figure 11). Based on calculated WQI values, the reverse interpolation approach (IDW) was used to create the spatial distribution of the water quality index map (Figure 12). Because it illustrates the spatial distribution as an index value for water quality, this map made it easy for decision-makers to evaluate water for drinking purposes over wide areas. It has been observed that the WQI for all water samples is within the second category (50-100) except sample 2 and 8 is just below the second category (<50). This indicated that the water in Habbaniya Lake is good for drinking purposes, and towards the center of the lake, the water becomes excellent.

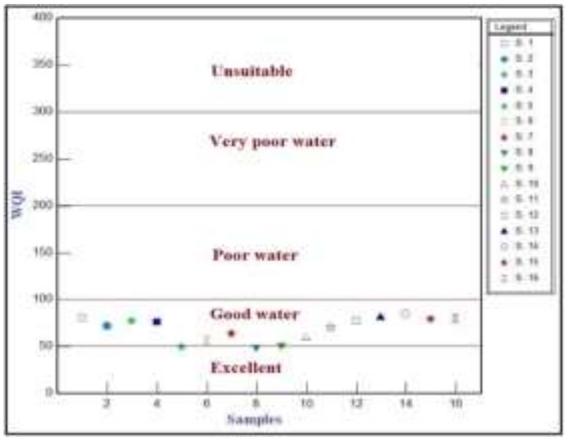

Fig. 11: Water quality classification according to the value ranges of WQI [28]

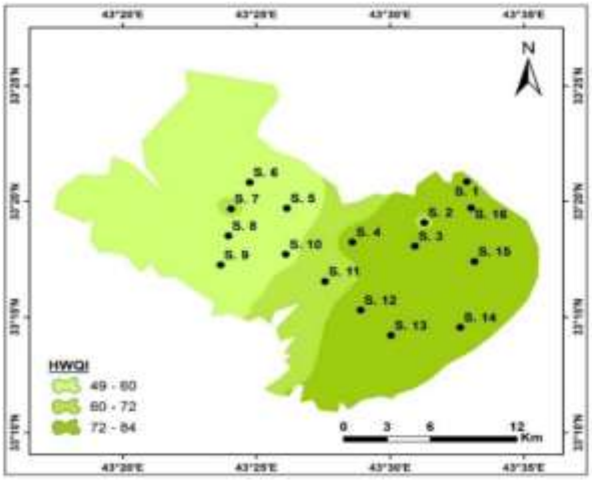

Fig. 12: Distribution of WQI in Habbaniya Lake

4. Conclusions

The WQI was utilized to total differing parameters and their measurements into a solitary score, showing an image of the water nature of Habbaniya Lake. To evaluate the nature of water quality in Habbaniya Lake for human utilization in an exact way, the human utilization WQI was made in the form of a map. This map gives a clear picture of the water quality distribution. The WQI for all samples in Habbaniya Lake is (50-100) and indicate that all water samples are good water for human drinking, except (S 5 and S 8), its value is just below the second category (<50), which mean that the water samples are excellent water for human drinking. The spatial distribution of WQI mapping was completed utilizing GIS. The spatial distribution of water quality is depicted on this map as the index value. Hence it is providing a clear and comprehensive view and shows the outcome that portrays the state of the water in the Habbaniya Lake. Because of the short-scope of WQI, the water quality of Habbaniya Lake has been considered as convergent water quality that fluctuated from excellent water to good water for human drinking.

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تطبيق تقنية نظم المعلومات الجغرافية (GIS) لتقييم مياه بحيرة الحبانية للاستهلاك البشري

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الخلاصة:

تم استخدام تقنية نظام المعلومات الجغرافية (GIS) في هذه الدراسة لإنتاج خريطة مؤشر جودة المياه (WQI) لتقييم مياه بحيرة الحبانية لأغراض الشرب. تم جمع ستة عشر عينة من المياه السطحية العذبة وتحليلها للتحقق من المعلمات الفيزيوكيميائية لمؤشر جودة المياه. تتضمن هذه المعلمات المواد الصلبة الذائبة الكلية، الأس الهيدروجيني، والكالسيوم، والمغنيسيوم، والصوديوم، والبوتاسيوم، والكلوريد، والكبريتات، والنترات. تم نقل نتيجة هذه المعلمات إلى منصة GIS لإنشاء قاعدة بيانات لجودة المياه ولإنتاج خريطة التوزيع المكاني لكل معلمة باستخدام تقنية (IDW). تم استخدام نتائج هذه المعلمات أيضًا لحساب قيم مؤشر جودة مياه الري، وتم نقلها إلى منصة GIS لإنتاج خريطة مؤشر جودة المياه. تمثل هذه الخريطة مؤشر التوزيع المكاني لمياه الشرب في بحيرة الحبانية. يوضح أن WQI لجميع عينات المياه تقع ضمن الفئة الثانية (50−100) باستثناء (5 S و 8 S) تحت الفئة الثانية (<50). يشير نطاق WQI القصير إلى أن جودة المياه في بحيرة الحبانية تعتبر نوعية مياه متقاربة تتأرجح من مياه ممتازة إلى مياه جيدة لشرب الإنسان. كما تبين أن الجزء الشمالي الغربي من بحيرة الحبانية هو الأنسب للشرب، حيث أن قناة الورار تصب في هذا الجزء، والتي تأخذ مياهها بشكل أساسي من نهر الفرات.