ISSN: 0974-5823 Vol. 7 No. 1 January, 2021

International Journal of Mechanical Engineering

Assessment of Drinking Water Quality for Euphrates River in Iraq using GIS

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Abstract. Thestudy'spurpose was to deem the (WQI) of the Euphrates in Iraq to assess its property for the sake of drinking usage. Water swabs were possessed from the Euphratesby(National Center for Water Resources Control). The samples were transported to the laboratory of (National Center for Water Resources Control) for analyses. Swab wasappreciating for ten parameters like pH, Total Dissolved Solid, Total Hardness, Sulphates, Nitrates, Biochemical Oxygen Demand, Electrical Conductivity, Calcium, Dissolved Oxygen and Chlorides. The deemwas done by using weighted arithmetic index process, In the process of monitoring the quality of water.

WQI was assessed in Table X based on the comparison of the results with the criteria in Table I as shown in Figure 11 and its spatial distribution in the maps (1,2,3,4) within four years.

In 2016, the value of WQI is not valid for human use except for Husiba.

In 2017, the value of WQI is valid for human use except forthe Kufa station.

In 2018 the WQI value for human use except for Kufa station.

In 2019 WQI is valid for human use except for Kufa and Samawah stations.

Keywords: Water Quality Index, Chemical-Physical-Biological Parameters, Weighted Arithmetic process, Euphrates.

Introduction

Water quality results by (National Center for Water Resources Control laboratory) (1), chemical, physical and biological testing of

water. Which is adopted as a measure of the state of water required for human use to maintain health, as best as possible.the traditional study takes great effort to collect samples of the water body with laboratory analysis, in addition to the big burden financially and materially (2).

Drinking water is closely linked to the spread of disease. It has been reported that 25 million people die each year from diarrhea and one-third of this number of children under the age of five have attributed this to waterborne pathogens(3). Water quality arises as a result of natural influences and human activities if any the quality of natural water can be low because it passes through geological strataA saline or gypsum concentration is high or is derived from the surface of the earth from saline or related layersThe chemical composition and salinity of the water is used as a basic function in the definition of water qualityAccording to different uses (4).

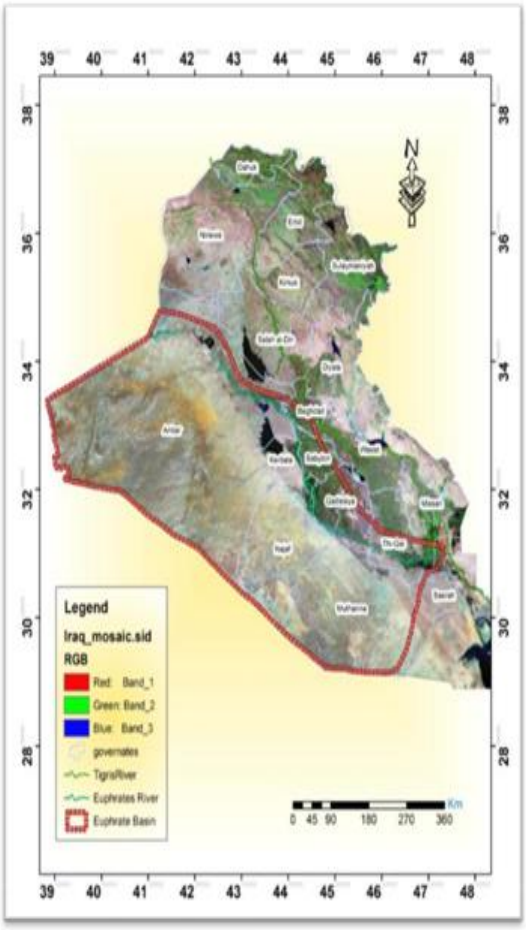
Water quality should be monitored to ensure that data is available to decision-makers to address the need to avoid increasing water pollution.

The water quality index is generally valid for specific sites within a specified time. The water quality index can be a means of comparing water to different sources so that the results can be clarified and how they change for several years and to which direction their quality can be directed.

Samples were taken from seven stations of the Euphrates, namely Husaybah, Haditha, Fallujah, Hindia, Kufa, Samawah, and Nasiriyah. For the years 2016 - 2017 - 2018 - 2019. The Euphrates is the main source of all human uses, agriculture, and industry for the central and southern governorates (Anbar, Karbala, Babylon, Najaf, Diwaniyah, Samawah, Nasiriyah, and Basra). Therefore, the study aims to assess the water quality of the Euphrates inside Iraq.

Study Area

Euphrates River, The longest river in southwest Asia, it is one of the two main constituents of the Tigris-Euphrates river system. The river rises in Turkey and flows southeast across Syria and through Iraq. Formed by the confluence of the Karasu and Murat rivers in the Armenian Highland, the Euphrates descends between major ranges of the Taurus Mountains to the Syrian plateau. It then flows through western and central Iraq to unite with the Tigris River and continues, as Shatt Al-Arab, to the Arabian Gulf. The length of the Euphrates from the source of the Murat River to the confluence with the Tigris at 3,000 kilometers (1,900 mi), of which 1,230 kilometers (760 mi) is in Turkey, 710 kilometers (440 mi) in Syria and 1,060 kilometers (660 mi) in Iraq. In length of the Shatt al-Arab, which connects the Euphrates and the Tigris with the Gulf, is given by various sources as 145–195 kilometers (90–121 mi). Euphrates River is located between the Sedimentary Plain in the east and the Western desert of Iraq in the west. Describes the Sedimentary Plain as a large sedimentary basin that represents a large syncline with active tectonic surface. This basin passes through a subsidence or depression, with small local elevation motions.(5)Map1 study area.



Map1. study area.

Methods and Calculations

The weighted arithmetic water quality index (WQIA) is in the following form:
$WQIA = \sum wiqini = 1/\sum wini = 1$ [1]
According to Brown et al (1972)[6], the value of qi is calculated using the following equation:
$qi = 100\ [(Vi - Vid) / (Si - Vid)]$ [2]
The quality rating for pH is calculated from the following equation:
$qpH = 100\ [(VpH - 7.0) / (8.5 - 7.0)]$ [3]
Where VpH= observed value of pH.
For dissolved oxygen is calculated from the following equation:
$qDO = 100\ [(VDO - 14.6) / (5.0 - 14.6)]$ [4]
Wi= K/ Si…….K= $1/(\sum 1/Si)$
As shown in Table II.

Table I below shows a classification of water quality, based on its quality index due to Brown (1972), Chatterji and Raziuddin (2002)(6), etc.

Table I. Classification of water quality method(5)

STATUS	WQI
Excellent	0 - 25
Good	26 - 50
Poor	51 - 75
Very Poor	76 - 100
Unsuitable for drinking	Above 100

Results

Table II gives values of the ten parameters of water swab (collected from January 2016 to December 2019), according to (WHO)(7).

Table II Results of (WQI).

Parameter	vi	vd	si	1/si	k	wi	qi	wiqi	WQI
pH	6.672	7	8.5	0.1176		0.2066	-21.87	-4.5187	
Electrical Conductivity	4927	0	250	0.0040		0.0070	1970.80	13.8468	
Total Dissolved Solids	4107	0	500	0.0020		0.0035	821.40	2.8856	
Total Hardness	1431	0	300	0.0033		0.0059	477.00	2.7928	
Calcium	186.7	0	75	0.0133		0.0234	248.93	5.8300	
Chlorides	748.7	0	250	0.0040		0.0070	299.48	2.1041	
Nitrates	1.2464	0	50	0.0200		0.0351	2.49	0.0876	
Sulphates	1266.7	0	200	0.0050		0.0088	633.34	5.5623	
Dissolved Oxygen	8.1627	14.6	5	0.2000		0.3513	67.06	23.5565	
BOD	1.765	0	5	0.2000		0.3513	35.30	12.4009	
				0.5693	1.7565	1.0000		64.5480	64.55

Tables III to IX show the results of laboratory tests for samples taken from monitoring stations, Form 2016 to 2019

TableIII.The result of water laboratory tests of Husaybah station.

Husaybah	2016	2017	2018	2019
PH	7.65	7.61	7.63	7.62
Electrical Conductivity	909.65	1083.575	996.6125	1040.09375
Total Dissolved Solids	581.227	602.81	592.02	597.417
Total Hardness	332.17	200	266	233
Calcium	80.065	80.065	78.5715	77.82475
Chlorides	131	108.02	119.51	113.77
Nitrates	4.14	4.14	4.14	4.14
Sulphates	195.26	195.26	195.26	195.26
Dissolved Oxygen	7.125	7.125	7.125	7.125
BOD	1.56	1.5	1.84	1.56

Table IV.The result of water laboratory tests of Haditha station

Haditha	2016	2017	2018	2019
PH	7.53	7.47	7.5	7.48
Electrical Conductivity	930.2	930.2	930.2	930.2
Total Dissolved Solids	621	574	598	622
Total Hardness	380.6	343.61	362.1	352.855
Calcium	78.4909	81.15	79.82	80.48
Chlorides	106.9136	81	94	87.5
Nitrates	3.07	3.15	3.11	3.13
Sulphates	233	212.208	222	206
Dissolved Oxygen	9.523	8.434	8.9785	8.70625
BOD	8.1	3	1.7467	2

Table V. The result of water laboratory tests of Fallujah station

Fallujah	2016	2017	2018	2019
PH	8.04	8.11	8.07	8.09
Electrical Conductivity	1094.37	1145.14	1150	1150
Total Dissolved Solids	97.3	126.2	122.8	117.7
Total Hardness	435	430	440	440
Calcium	84	91.65	78.82	89.23
Chlorides	119.89	135.94	127.91	131.925
Nitrates	3.7355	3.71	3.72	3.71
Sulphates	202.9	217.6	210.25	213.92
Dissolved Oxygen	8.573	7.7795	8.05175	7.91563
BOD	7.6	2	1	2

Table VI.The result of water laboratory tests of Hindia station.

Hindia	2016	2017	2018	2019
PH	7.87	7.895	7.482	7.9
Electrical Conductivity	1094.365	1145.14	1150	1150
Total Dissolved Solids	97.3	126.2	122.8	117.7
Total Hardness	517	409.8	484.7	429
Calcium	103.4183	88.34	107.2	86.33
Chlorides	130.37	128.2	153.2	128.8
Nitrates	4.7505	1.688	5.061	1.53
Sulphates	327.14091	311.7	345.5	307.7
Dissolved Oxygen	9.048	8.25	8.51513	8.31094
BOD	10.15	4.55	2.6	4.601

Table VII.The result of water laboratory tests of Kufa station.

Kufa	2016	2017	2018	2019
PH	7.48	7.791	7.425	7.79
Electrical Conductivity	1585	1399	1517	1508
Total Dissolved Solids	26.0	32.6	18.6	54.4
Total Hardness	538	473.8	498.5	473.8
Calcium	146.067	120.6	144.3	120.6
Chlorides	140.162	152.8	187.3	152.8
Nitrates	2.785	1.236	4.961	1.236
Sulphates	396.916	367.2	362.4	367.2
Dissolved Oxygen	8.835	9.13	8.28344	8.11328
BOD	10.5	9	9	6.368

Table VIII.The result of water laboratory tests of Samawah station.

Samawah	2016	2017	2018	2019
PH	7.89	7.87	7.963	7.87
Electrical Conductivity	4039.62	3581	4781	1397
Total Dissolved Solids	2678	2332	2331	3038
Total Hardness	1058	906	1136	983
Calcium	229.964	191.8	243.8	191.76
Chlorides	826.47	662.4	864.2	662.41
Nitrates	4.27855	1.246	4.676	1.2464
Sulphates	673.848	752.1	752.1	617.38
Dissolved Oxygen	8.263	10	8.39928	8.21211
BOD	10.15	2.67	2.15	5.6253

Table IX. The result of water laboratory tests of Nasiriyahstation.

Nasiriyah	2016	2017	2018	2019
PH	9.2	7.778	7	6.672
Electrical Conductivity	4692.4	4927	7173	4927
Total Dissolved Solids	2717	2684	2684	4107
Total Hardness	966	1040	1476	1431
Calcium	183.417	186.7	139.6	186.7
Chlorides	773.75	748.7	1297	748.7
Nitrates	4.27855	1.246	4.676	1.2464
Sulphates	681.455	736.4	977.4	1266.67
Dissolved Oxygen	7.942	5.85	8.34136	8.1627
BOD	2.11	1.94	1.59	1.765

The following table shows the maximum and minimum value of the elements according to the results of the test of samples in the laboratory, their location and the year of the test.

Table X. The result of water laboratory tests of Nasiriyahstation.

No.	Element	Max.			Min.		
		value	year	station	value	year	station
1	Ph	9.2	2016	Nasiriyah	6.672	2019	Nasiriyah
2	Ec	7173	2018	Haditha	930.2	2018	Nasiriyah
3	TDS	4107	2019	Nasiriyah	581.2	2016	Husaybah
4	TH	1476	2018	Nasiriyah	200	2017	Husaybah
5	Ca	243.8	2018	Samawah	78.8	2018	Fallujah
6	Cl	1297	2018	Nasiriyah	106.9	2016	Haditha
7	No3	5	2018	Hindia	1.24	2017	Samawah
8	So4	1266	2019	Nasiriyah	195	2016	Husaybah
9	Do	10	2017	Samawah	5.85	2017	Nasiriyah
10	Bod	10.5	2016	Kufa	1	2018	Fallujah

Figures 1 to 10 show the comparison between the results of laboratory tests for each of the elements for each of the stations from 2016 to 2019.

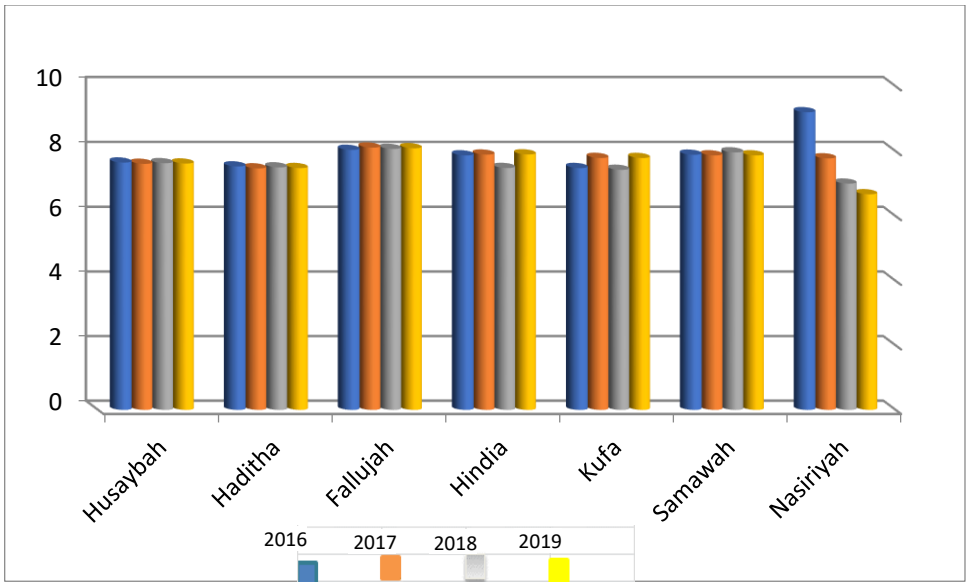


Figure1.PH value for 7 stations along the Euphrates

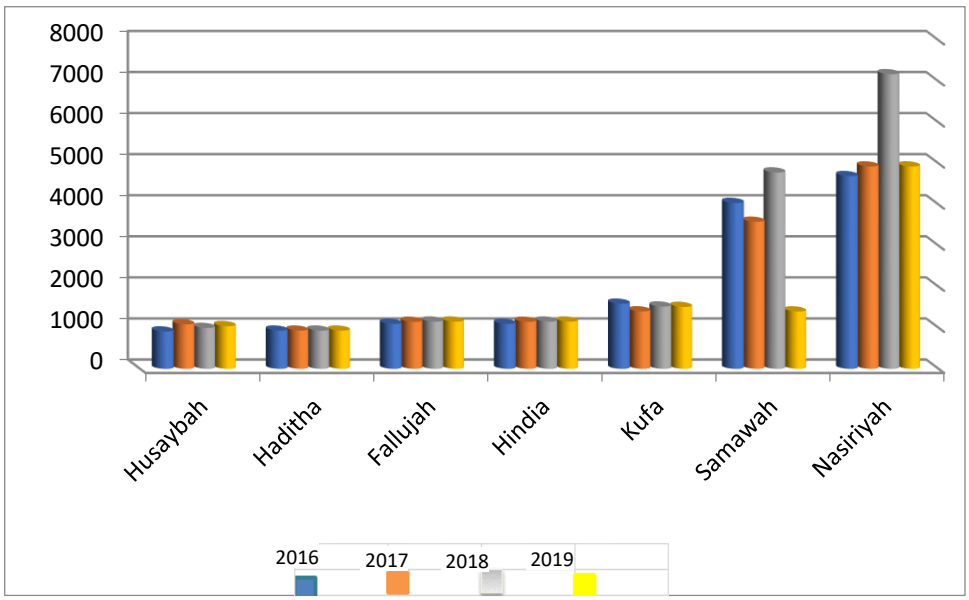


Figure2. Ec (ppm) value for 7 stations along the Euphrates

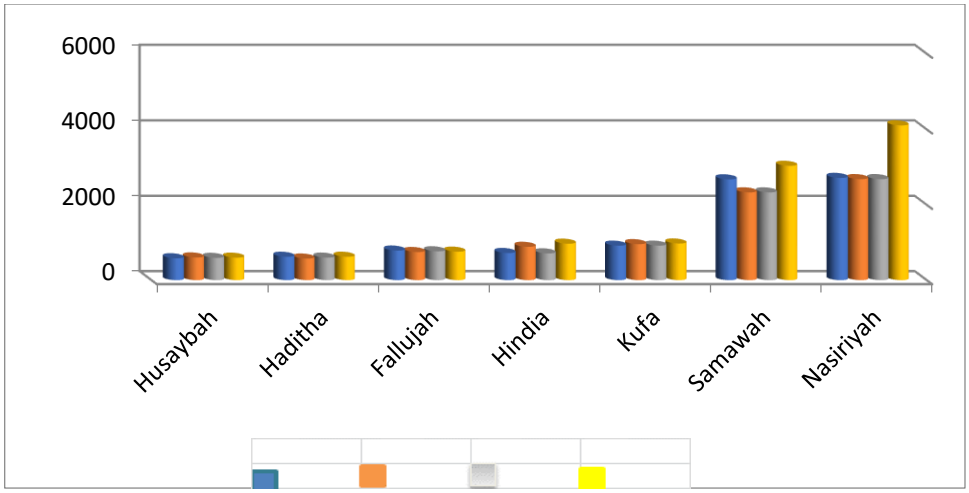


Figure3. TDS (ppm) value for 7 stations along the Euphrates

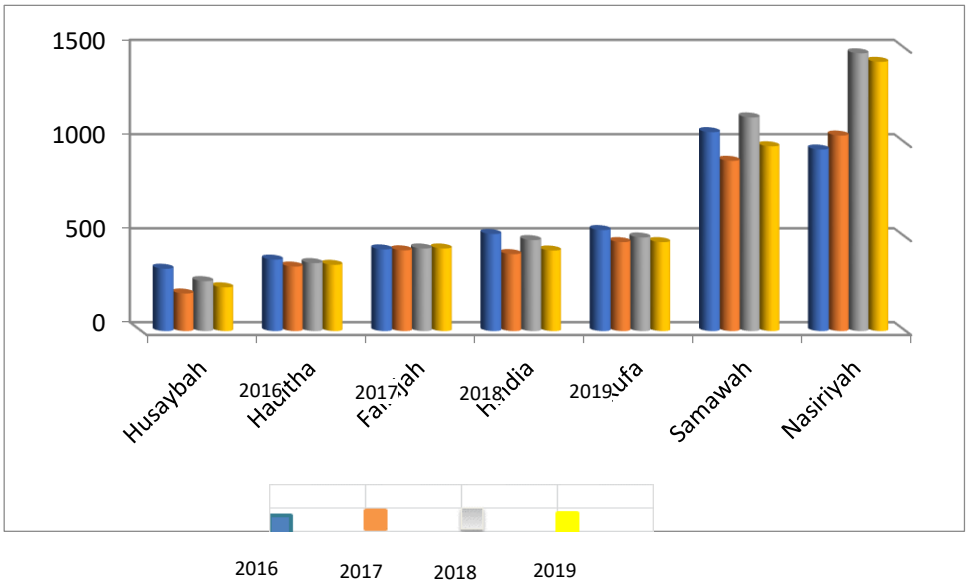


Figure4. TH(ppm) value for 7 stations along the Euphrates

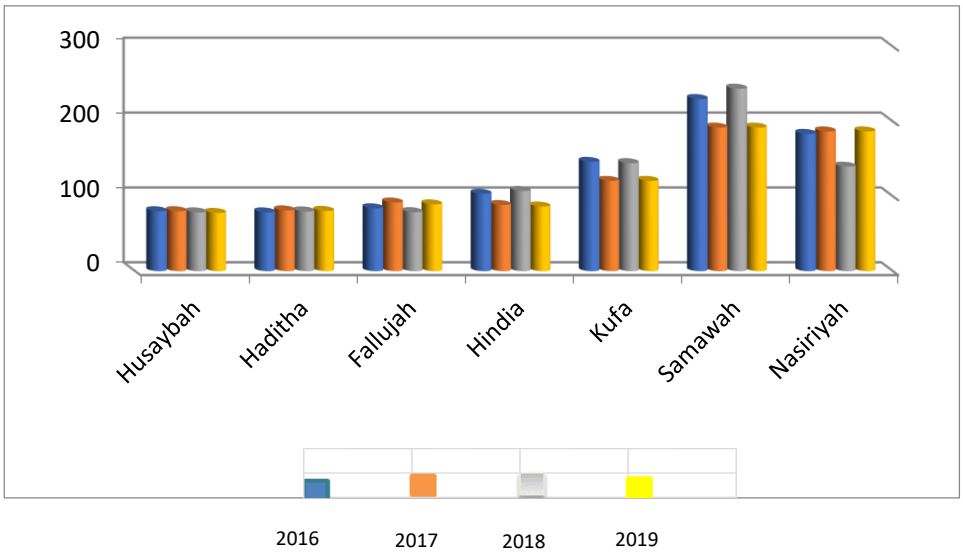


Figure5. Ca(ppm) value for 7 stations along the Euphrates

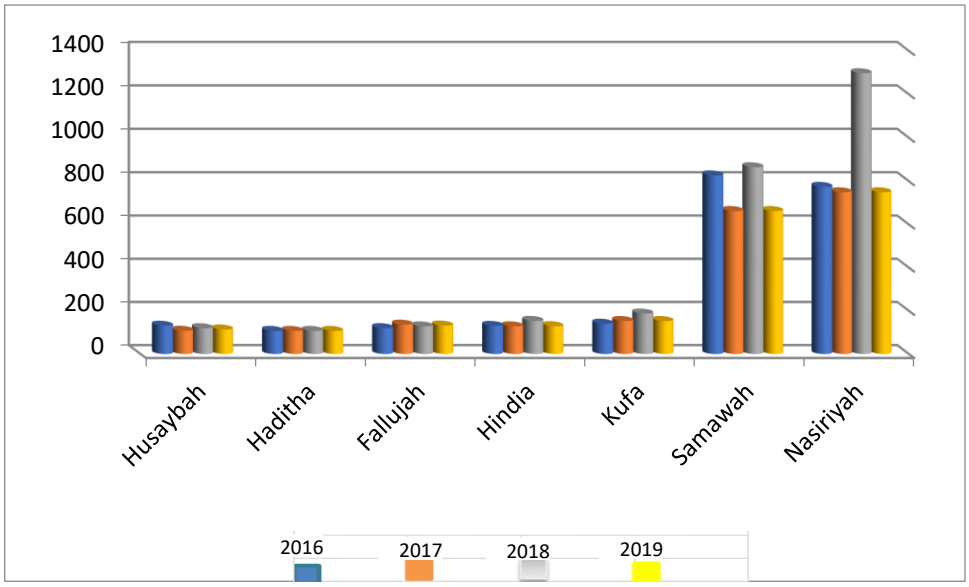


Figure6.CL(ppm) value for 7 stations along the Euphrates

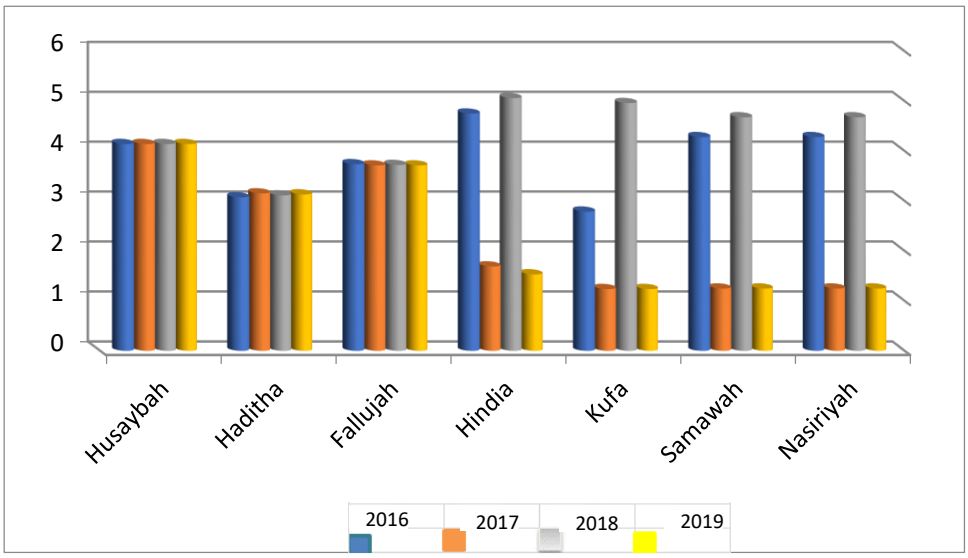


Figure7. No3(mg/L) value for 7 stations along Euphrates

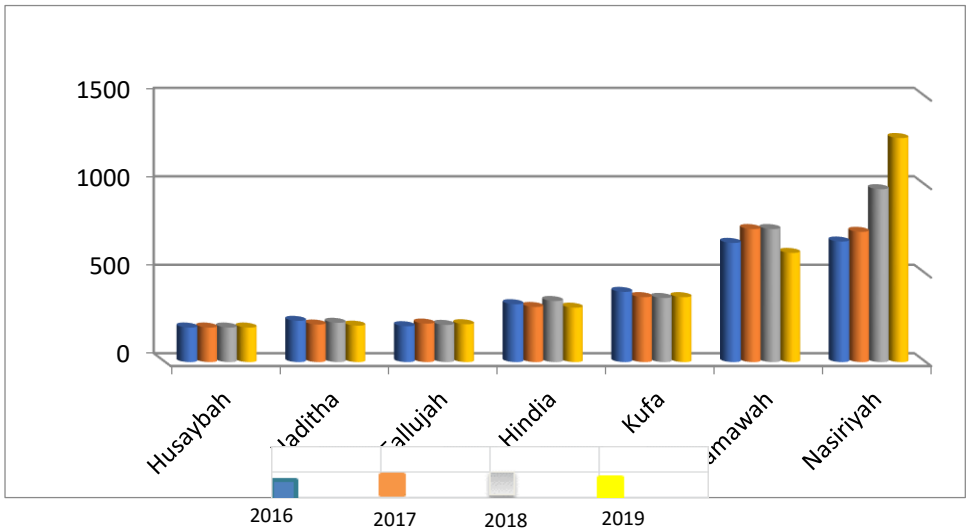


Figure 8.SO4(ppm) value for 7 stations along the Euphrates

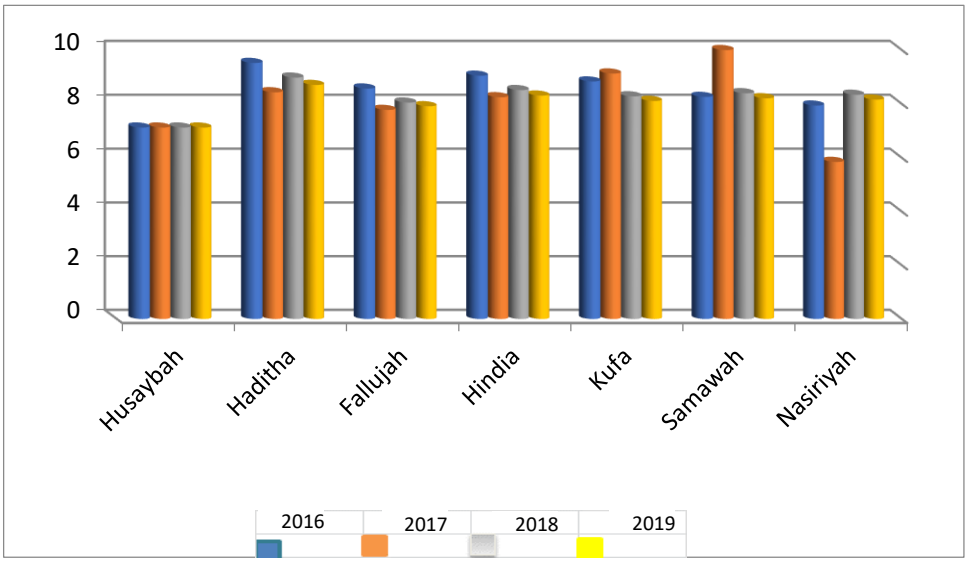


Figure9. Do(mg/L) value for 7 stations along the Euphrates

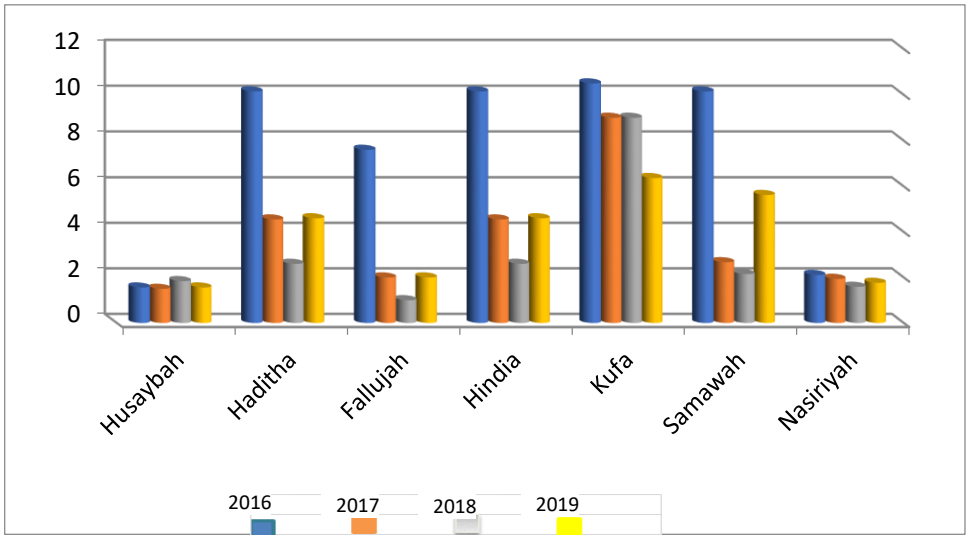
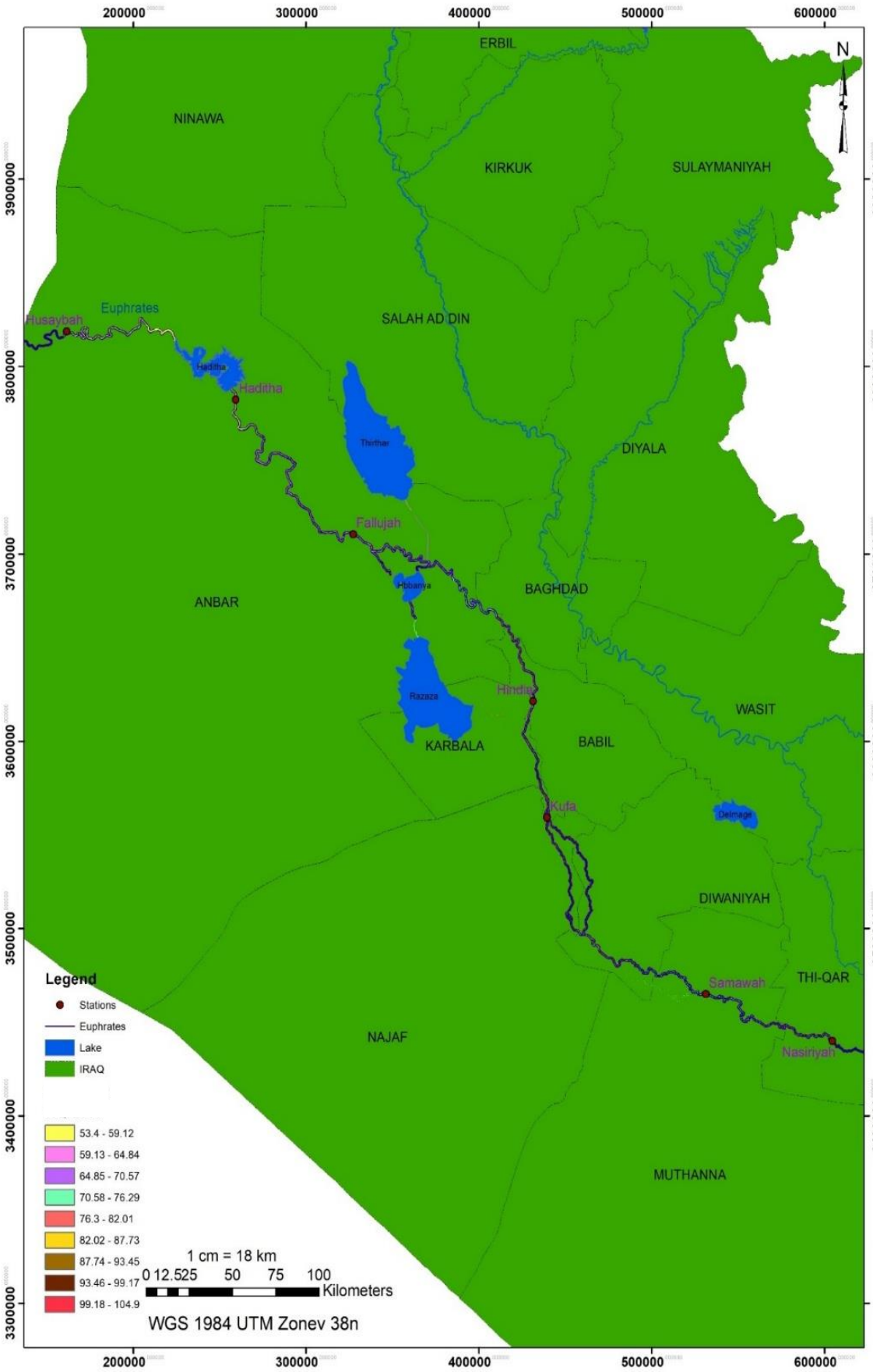


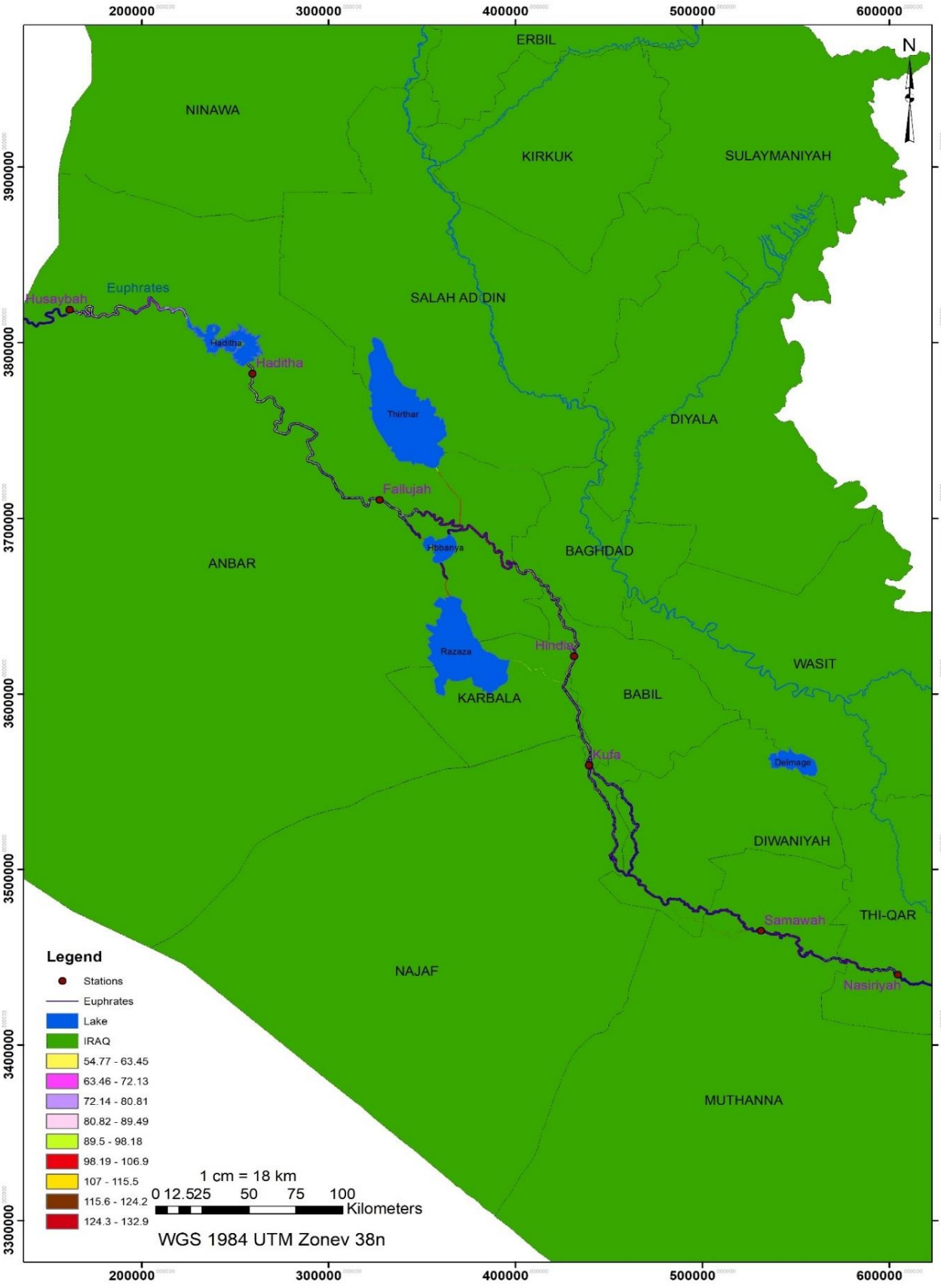
Figure10. BOD(mg/L) value for 7 station along Euphrates

After obtaining (WQI) results for all monitoring stations for the years 2016, 2017, 2018, and 2019, GIS techniques were used to represent them on the maps of the study area, where they show the change that occurred during those years spatially. As shown in maps 1 to 4.

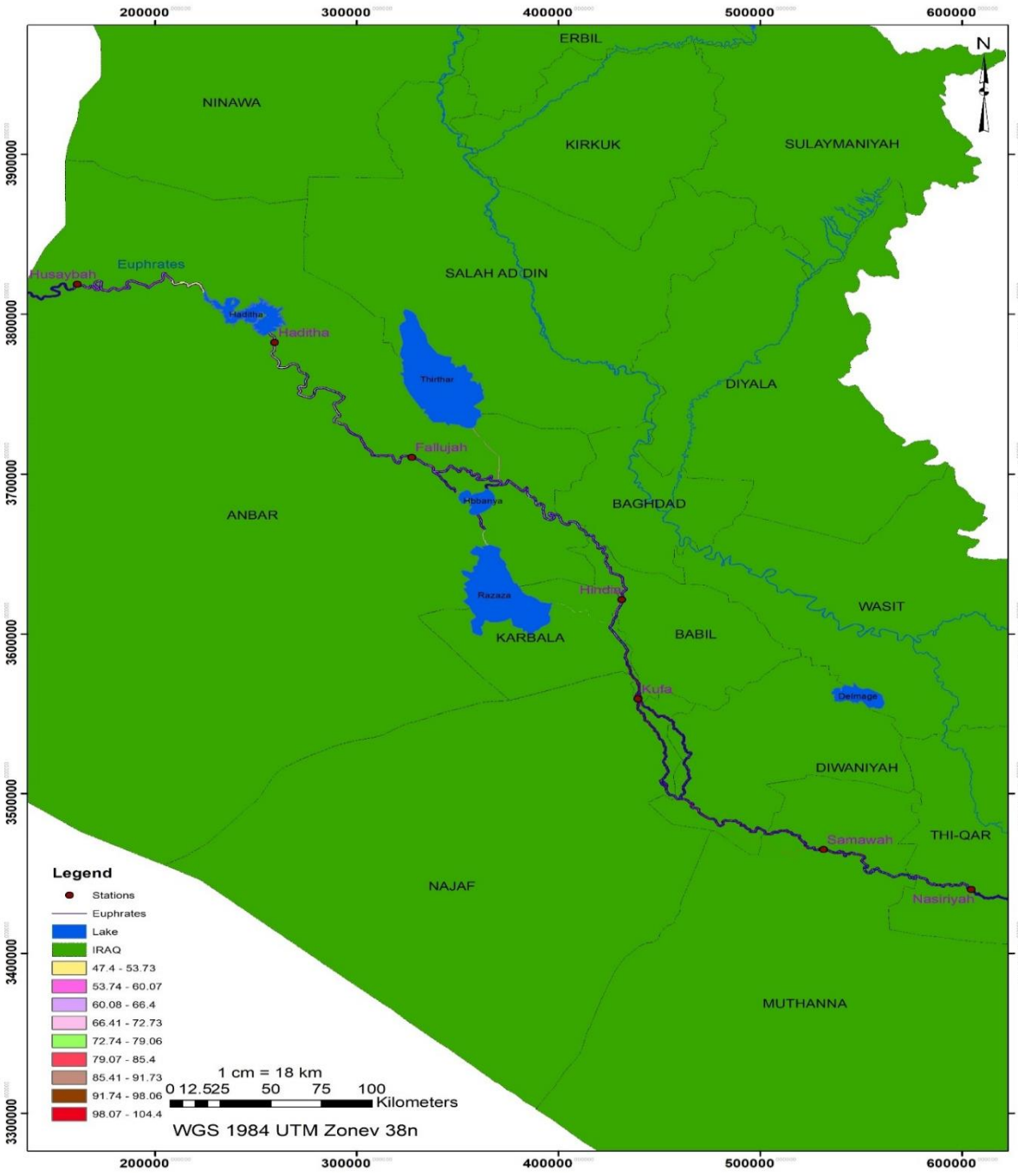
Map 2. the spatial distribution of WQI in 2016



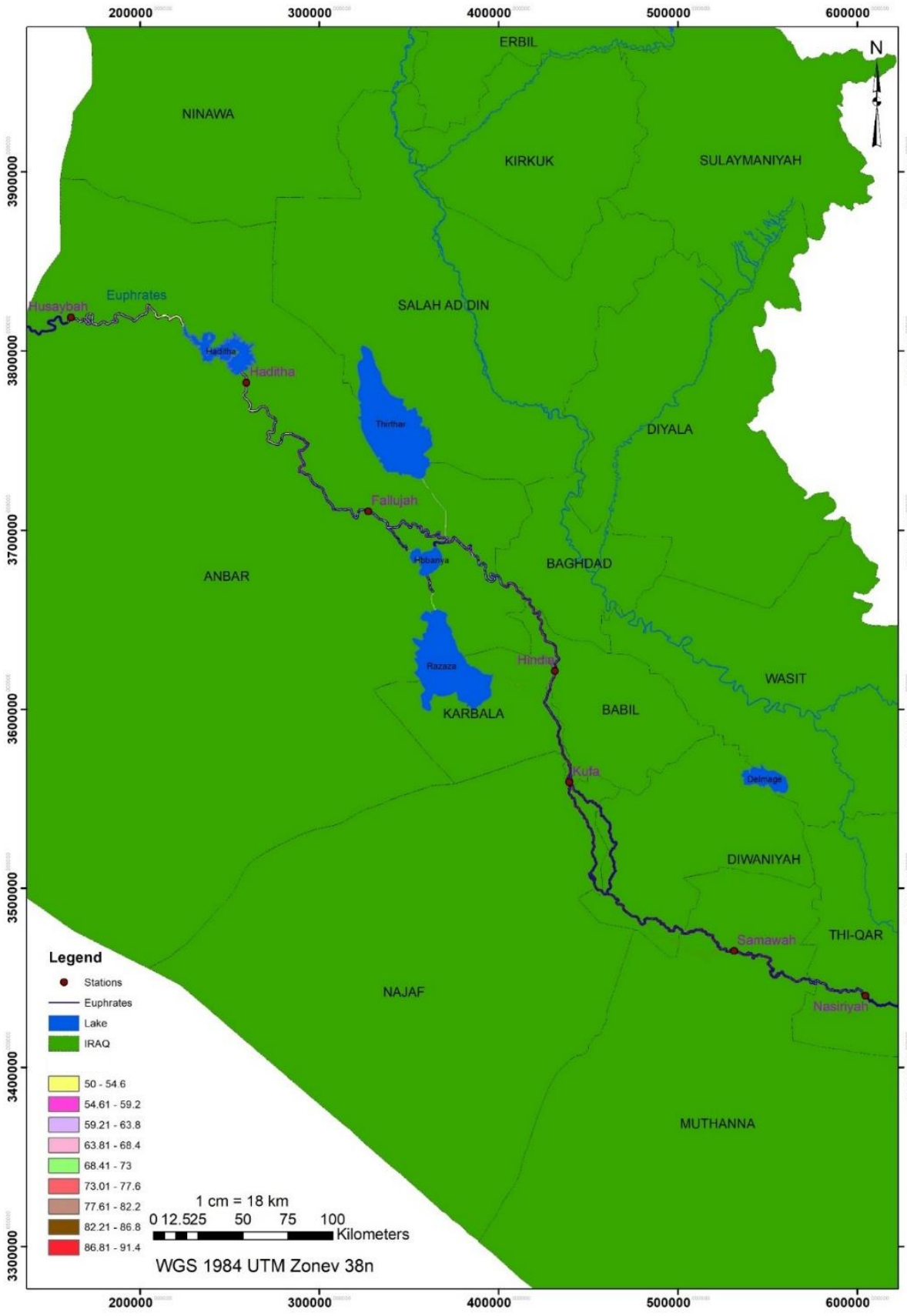
Map 3. the spatial distribution of WQI in 2017



Map 4. the spatial distribution of WQI in 2018



Map 5. the spatial distribution of WQI in 2019



Conclusion

After collecting the data for seven stations along the Euphrates for the years 2016 to 2019 data.Calculations were made according to the weighted arithmetic water quality index to extract the values of WQI for all stations and four years.

When the results were extracted and represented in diagrams, the data were entered to ArcGIS 10.7.1 for analysis and graphical representation on the map through interpolation technique, giving it a temporal and spatial quality of WQI for each year according to the data entered and its validity for human use as drinking water after comparing it to standards shown in Table I to maintain the health of the population.As shown in Table XI. and Figure11.

The results can be illustrated as follows:

1. Inthe Husaybah station shown in the maps, WQI values range from (54.11 to 56.63). These values as within the criterion of poor and are suitable for human use.
2. In Haditha station there is fluctuation in the values of the results. In 2016,the value of the results of WQI 90.57 is within the criterion very poor, which means an increase in the percentage of pollution, but still within the acceptable value of human consumption. In 2017, the value of WQI 57.72 is in poor criterion. In 2018 and 2019, the values are less than 50 and this is within the Good criterion and is within the acceptable value of human consumption.
3 - At Fallujah station,the result has a great convergence with Haditha station where the highest value of WQI 98.37 It is in very poor criterion. In 2016 while in the other three years, it is in the poverty criterion as in the maps and it is still within the accepted standard of human consumption.
4- At Al Hindia station the highest value of WQI 112.69 for 2016, which indicates that the level of pollution in drinking water makes it unsuitable for human use. For the rest of the years, the criterion is between poor and very poor and is within the permissible range of human consumption.
5- At Kufa station, the WQI value for the years between 2016 and 2018 is within the criterion that is not suitable for human consumption because of the high percentage of pollution. While in 2019 we find the WQI 91 value and is within the very poor standard and is within the limits allowed for human consumption.
6. In Samawah station, in 2016, the value of WQI 134.8 is the highest among all stations and for the four years. This indicates a large value for water pollution and its non-human consumption. For the rest of the years, the standard is poor and very poor within the limits allowed for human consumption.
7 - In Nasiriyah stationthe values of WQI between 64.53 and 97.6, which are between the poor and very poor and are within the limits allowed for human consumption.

It is very important to show that the main causes of pollution in the Euphrates are:

1. The discharge of high-salinity water containing pesticides to the Euphrates.
2. Sewage discharge to the Euphrates.
3. In areas with low runoff, water pollution is increased.
4. At times when the water levels are low because of their reservations in the dams to fill reservoirs or lack of discharges from the upstream countries also adversely affect the water, which increases the percentage of pollution.
5. Climate change, which causes high temperatures and lack of rain, also increases the Euphrates pollution.
6. Increasing the number of aquatic plants in the Euphrates such as the Nile flower (Eichhornia) and Champlain (Ceratophyllum) in the river basin leads to the consumption of large quantities of water and thus increase the percentage of pollution.
7. The presence of tourist facilities, restaurants, and agricultural land around the water source causes pollution due to the discharge of sewage .

Table XI. Water Quality Index (WQI) values.

	station	X	Y	WQI			
1				2016	2017	2018	2019
2	Husaybah	161311.6991	3818810.25	54.9	54.11	56.63	54.55
3	Haditha	259121.1891	3782312.086	90.57	57.72	47.4	49.86
4	Fallujah	327205.1596	3710475.692	98.37	63.35	54.36	62.51
5	Hindia	431195.3671	3621410.932	112.69	76.78	57.5	77
6	Kufa	439204.8989	3559242.85	114.5	105.5	105	91
7	Samawah	531253.0567	3464953.873	134.8	72.29	82	93.5
8	Nasiriyah	604542.465	3439902.931	97.6	85.3	71.6	64.55

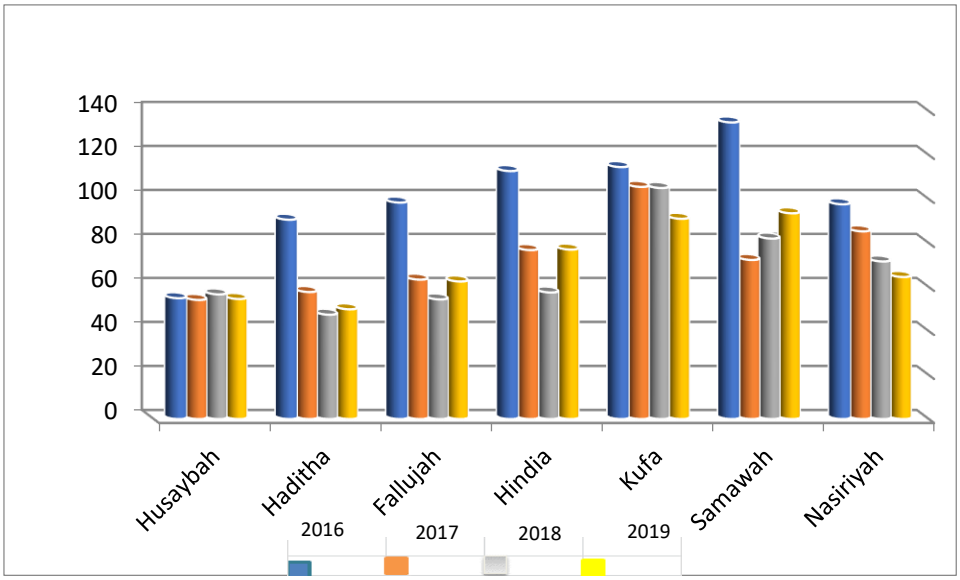


Figure11. WQI value for 7 stations along the Euphrates

Recommendation

Due to the non-validity of drinking water according to the results of WQI for all stations for 2016 except for Husiba station, and non-validity of Kufa station for all years, and non-validity at 2019 for the stations of Kufa and Samawa, should take the following actions because it directly affects human life and health.

1. Strict measures must be taken that would contaminate the sources of the Euphrates River.

2. Preventing the unprocessed access of spring water to the Euphrates River, as well as strict restrictions to prevent sewage from reaching the river without treatment.
3. Spreading health awareness among citizens of the seriousness of the use of contaminated water.

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