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ASSESSMENT OF SHATT AL ARAB WATER QUALITY USING WATER QUALITY INDEX ANALYSIS

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Abstract

Water quality index (WQI) is a unique value indicator used to assess overall water quality in a single term. [1]This study aims to assess the water quality of Shatt al Arab (south of Iraq) for drinking purposes for the period 2014-2018 using the weighted arithmetic WQIR method. Samples were taken from five monitoring stations on Shatt al Arab and fourteen physical and chemical parameters were analyzed. Spatial analyses were done using the Geographic Information System (GIS) to map the water quality index results. More river parts were found to be between good and poor qualities in 2014 whereas all of them were unsuitable for drinking in 2017 and 2018.

Keywords: WQI, GIS, Weighted Arithmetic Index, Water Quality.

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Introduction

Water has a great self-generating capacity that can neutralize polluting human interventions. However, if human activities continue this uncontrolled and unsustainable exploitation of this resource, this ability to regenerate will fail and be permanently endangered. [2]

Assessment of surface water quality can be a complex process undertaking multiple parameters capable of causing various stresses on overall water quality. Evaluating water quality from a number of samples containing concentrations of a number of parameters is difficult process. [3] Several water quality indicators have been formulated around the world that can easily judge the overall water quality within a given area quickly and efficiently. [4]

WQI is a mathematical tool used to transform large quantities of water quality data into a single number that represents water quality level. WQI can give information about whether the overall quality of water contributes a possible threat to different uses of water, such as habitat for aquatic life, irrigation, and drinking purpose. It incorporates the data pool generated after collecting due weights to the different variables. [5]

The Arithmetic weighted index method is characterized over other methods. In this method multiple water quality parameters are integrated into a mathematical equation that measures water health through a number known as water quality index as well as it represents the suitability of surface and groundwater for human consumption. [6]

This study aims to use the arithmetic weighted index method in evaluating Shatt al Arab water quality for drinking purposes.

Study area

The study area belongs to Shatt al Arab south of Iraq shown in figure (1). It lies between longitude30º 24' 26" N and latitude 48º 09' 06" E. It forms from the confluence of Tigris and Euphrates rivers at Al Qurna (about 70 Km north the city of Basra) and continues to Al-Fao town (about 90 Km south of Basra city) where the Shatt Al-Arab empties into Arabian Gulf.[7] The total length of the river is 195 km and its drainage area is 80,800 km2.The river receives freshwater from four main tributaries. In addition to the Tigris and Euphrates, Karun and Karkha Rivers usually contribute 24.5 and 5.8 billion cubic meters annually respectively.[8]In the recent five years, Shatt Al-Arab sustains from collapsing in water quality due to the severe decline in sewage networks, pesticide products, low discharge from tributaries, and the tidal effect from the Arabian gulf.

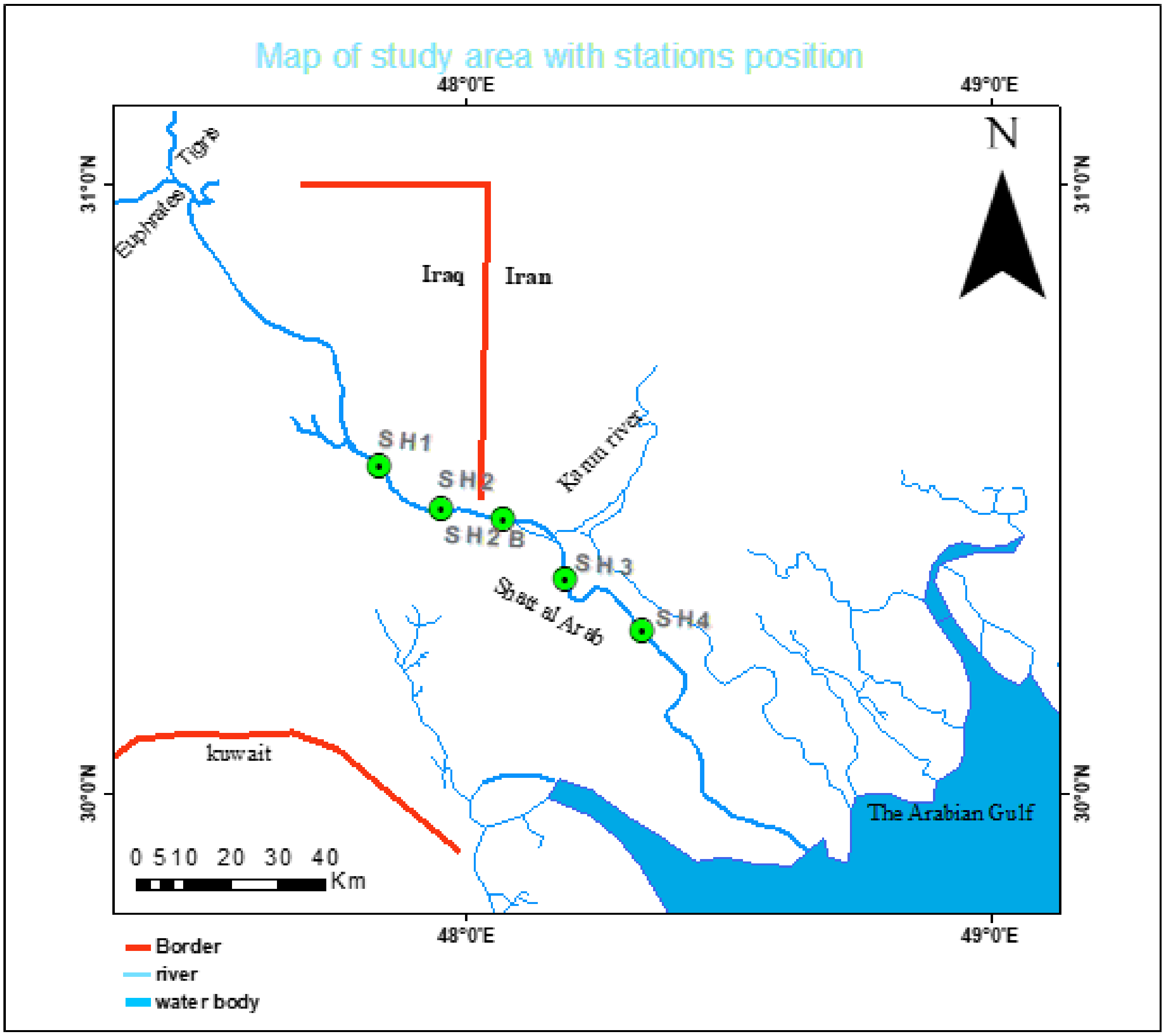


Figure (1): Map of study area, Shatt al Arab River, and surrounding area. [By researcher]

Material and Method

The data from five monitoring stations on Shatt al Arab were obtained from the Iraqi ministry of environment for the period from 2014 to 2018 to assess the river water quality and its suitability for drinking purpose. The data contained a concentration of fourteen physical and chemical parameters taken from the five stations monthly. These parameters are hydrogen ion concentration (PH), dissolved oxygen (DO), Phosphate (Po4), total hardness (TH), total dissolved solids (TDS), chloride (Cl), magnesium (Mg), calcium (Ca), sulfate (So4), nitrate (No3), potassium (K), sodium (Na), alkalinity (ALK.), and electrical conductivity (EC). The mean annual rates of each parameter were calculated in each station and used in WQI calculation using the weighted arithmetic index method.

The arithmetic weighted water quality index method distributed the water quality according to the class of purity using the most commonly measured water quality parameters. The calculation of WQI was done using the following formula [9]:

$WQI\ aw = \sum Qi\ Wi / \sum Wi$ …… (1)

Where:

Qi is the quality rating scale.

Wi is the unit weight

The quality rating scale can be calculated by:

$Qi = 100\ [Vi - Vo / Si - Vo]$ ……(2)

Where:

Vi is the estimated concentration of ith parameter in the analyzed water.

Vo is the ideal value of a parameter in pure water.

Knowing that the ideal value equal to zero for all parameters except that for PH which is 7 and that for DO is 14.6.

Si is the recommended standard value of i th parameter.

The unit weight Wi is inversely proportion to standard value Si, so it can be calculated by:

$Wi = K/Si$ …… (3)

Where K is the proportionality constant, it can be calculated by:

$K = 1/ \sum (1/Si)$ ……(4)

The unit weight and k parameter calculation method can show in the table (1).

4. Results and discussion

Samples from five monitoring stations on Shatt al Arab for the period 20142018 were collected and analyzed for different water quality parameters by the Iraqi ministry of environment every month.

The mean annual rates of each parameter across the five monitoring stations were calculated by the researcher and used in the next mathematical process.

After the calculations of the quality rating scale Qi and k parameter using equations (2,4) respectively as shown in table(1), WQI for the five stations was evaluated using equation(1). The results of WQI (see table (2)) in the five stations for the period 2014 -2018 were analyzed using the Microsoft excel program as shown in figure (2).

Table (1): Calculation of K parameter and unit weight Wi

parameter	Sn	1/Sn	k	wn
PH	8.5	0.117647	0.263009	0.030942
DO2	5	0.2		0.052602
PO4	0.3	3.333333		0.876698
NO3	50	0.02		0.00526
Ca	200	0.005		0.001315
Mg	50	0.02		0.00526
TH	300	0.003333		0.000877
K	12	0.083333		0.021917
Na	200	0.005		0.001315
SO4	250	0.004		0.001052
CL	250	0.004		0.001052
TDS	1000	0.001		0.000263
EC	2000	0.0005		0.000132
Alk.	200	0.005		0.001315
		Σ 1/Sn = 3.802147		Σ wn =1

Table (2):Water quality index values for the period 2014-2018 across the monitoring station

Station Code	2014	2015	2016	2017	2018
SH1	38.55944	81.04678	61.879	122.8299	105.8907
SH2	56.9166	109.5654	70.11704	137.2484	175.5525
SH2B	45.26573	68.88398	40.01498	171.4094	112.8136
SH3	45.72199	61.38103	90.07017	186.619	141.1387
SH4	60.12741	113.4763	129.4989	160.654	218.8608

The WQI results were categorized into different classes according to arithmetic weighted of WQI classification as shown in tables (3, 4). Maps were built to illustrate the status of water quality along the surface water as shown in figure (3).

Table (3): classification of water quality according to arithmetic weighted of WQI method (Chatterji and Raziuddin, 2002).

WQI Level	Water Quality Status
0 -25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
>100	Unsuitable for drinking

Table (4): water quality status in study area.

Station	2014	2015	2016	2017	2018
SH1	Good	Very poor	poor	unsuitable	unsuitable
SH2	Poor	unsuitable	poor	unsuitable	unsuitable
SH2B	Good	poor	good	unsuitable	unsuitable
SH3	Good	poor	Very poor	unsuitable	unsuitable
SH4	Poor	unsuitable	unsuitable	unsuitable	unsuitable

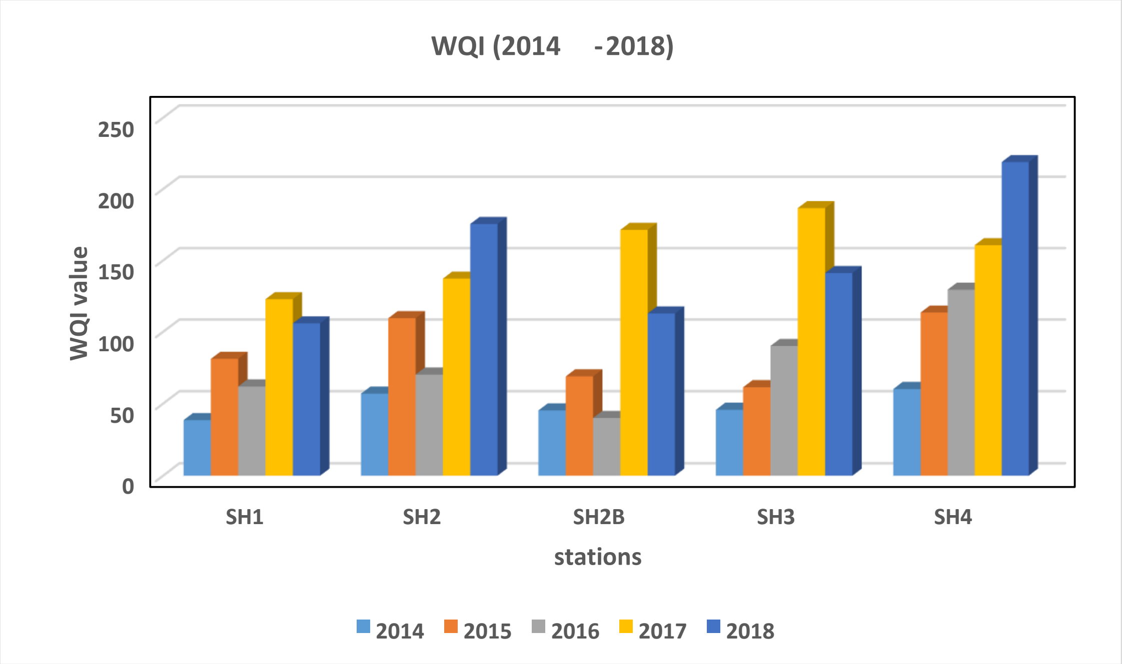


Figure (2): WQI analysis for the period 2014-2018.

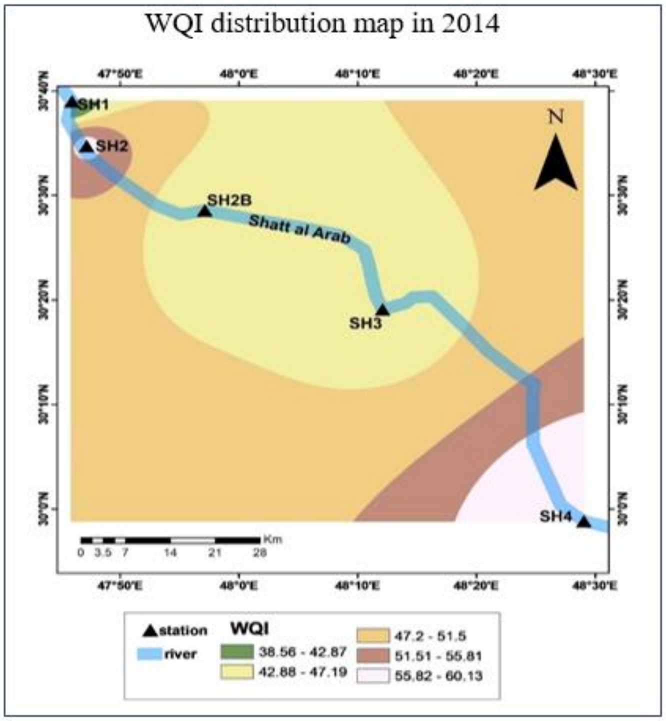
GIS technique was used in this study to build color maps illustrate the spatial distribution of WQI results along the river.

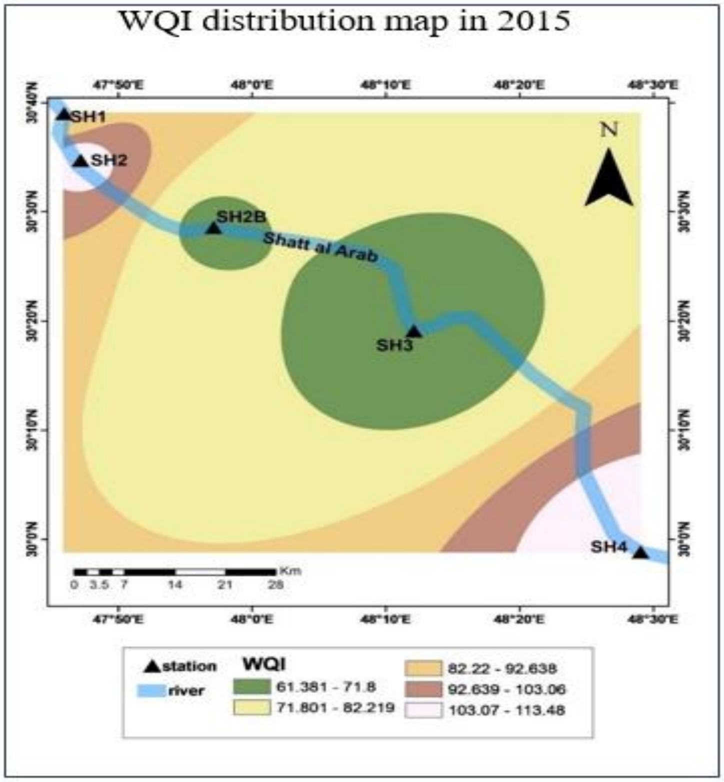
Inverse distance weighted IDW technique is one of the spatial analysis tools in ArcMap software 10.6.1. It was used in this research to build maps of WQI as shown in figure (3).

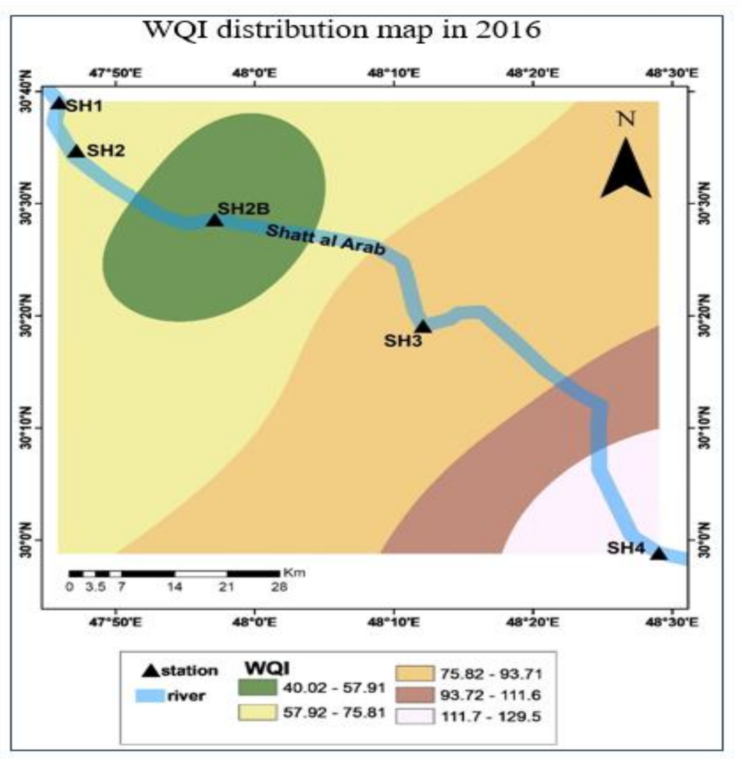
The distribution maps of WQI illustrated spatial and temporal variations across the study area where the WQI recorded the lowest value in 2014 at all stations. Then, this value arose in 2015 and at all stations also.

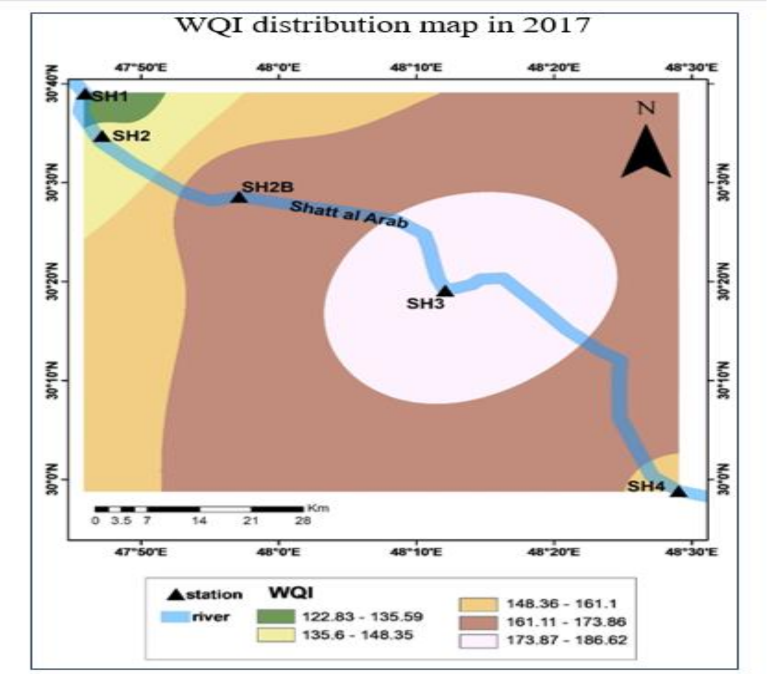
In 2016, the value of WQI was decreased at the first three stations and increased at the last two stations.

In 2017, highly increase in WQI value at all stations. Whereas an increase occurs in the second and fourth stations only in 2018.


WQI distribution map in 2014
47°50'E
48°0'E
48°10'E
48°20'E
48°30'E
30°40'N
30°30'N
30°20'N
30°10'N
30°0'N
N
SH1
SH2
SH2B
Shatt al Arab
SH3
SH4
0 3.5 7 14 21 28 Km
station
river
WQI
38.56 - 42.87
42.88 - 47.19
47.2 - 51.5
51.51 - 55.81
55.82 - 60.13


WQI distribution map in 2015
47°50'E
48°0'E
48°10'E
48°20'E
48°30'E
30°40'N
30°30'N
30°20'N
30°10'N
30°0'N
N
SH1
SH2
SH2B
Shatt al Arab
SH3
SH4
0 3.5 7 14 21 28 Km
station
river
WQI
61.381 - 71.8
71.801 - 82.219
82.22 - 92.638
92.639 - 103.06
103.07 - 113.48


WQI distribution map in 2016


WQI distribution map in 2017

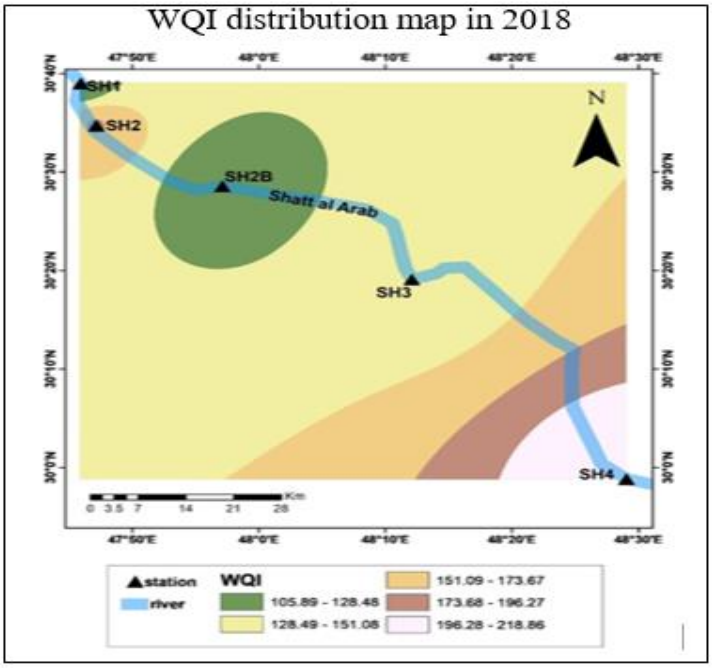
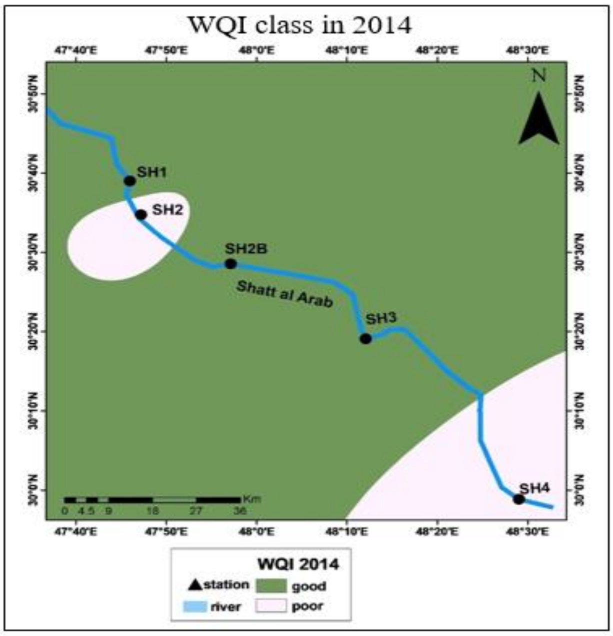
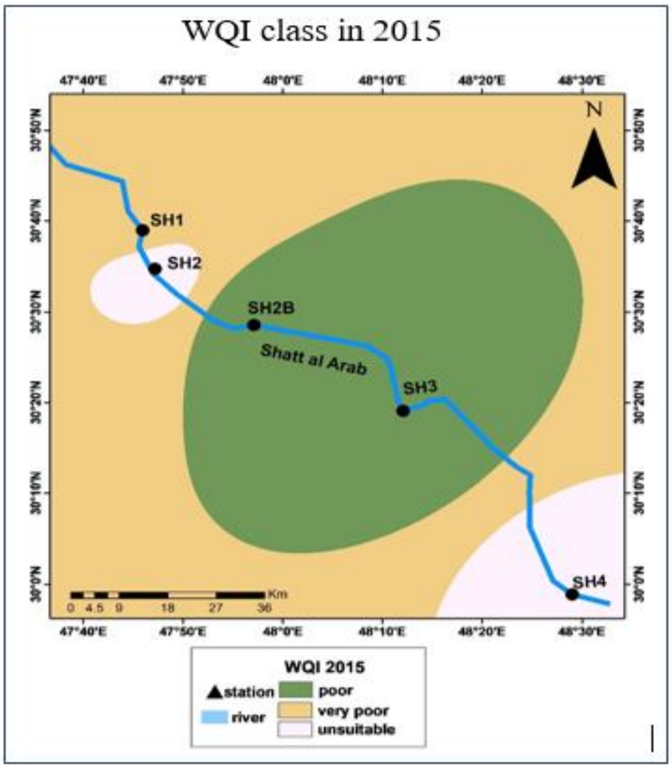
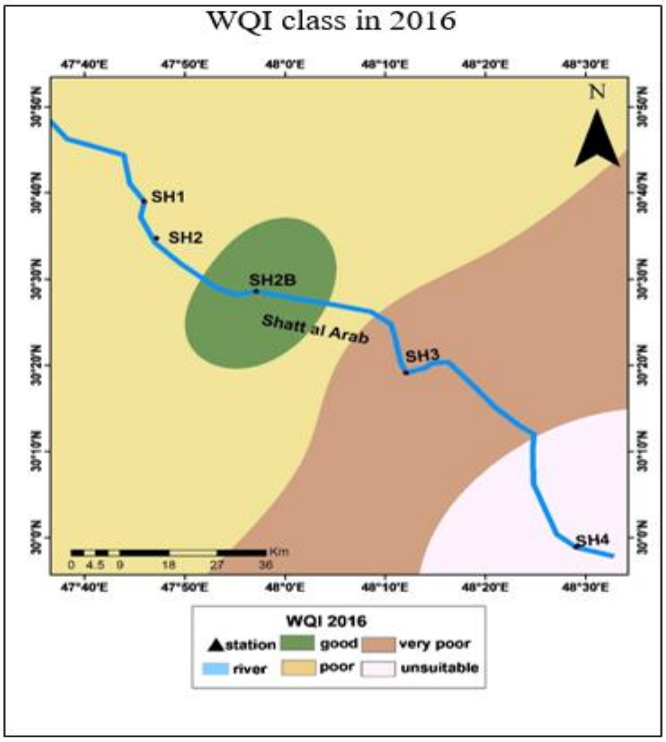


Figure (3): Distribution maps of WQI results along the study area.

Also, ArcMap GIS was used to classify the region into some categories illustrate different water quality along the river as shown in figure (4).
Classification maps of WQI illustrate that most of the river's water of good quality in the year 2014.
In 2015, the water is unsuitable for drinking in second SH2 and fourth SH3 stations whereas the remaining parts of the river belong to poor and very poor water quality.
Most parts of the river in 2016 were of poor and very poor quality except the third station SH2B was of good quality and the last station was unsuitable.
In the years 2017 and 2018, there was a water quality collapse where WQI has recorded values greater than 100 in all stations i.e. the river water was unsuitable for drinking.




WQI class in 2015
47°40'E
47°50'E
48°0'E
48°10'E
48°20'E
48°30'E
30°50'N
30°40'N
30°30'N
30°20'N
30°10'N
30°0'N
N
SH1
SH2
SH2B
Shatt al Arab
SH3
SH4
0 4.5 9 18 27 36 Km
WQI 2015
station
river
poor
very poor
unsuitable


WQI class in 2016
47°40'E
47°50'E
48°0'E
48°10'E
48°20'E
48°30'E
30°50'N
30°40'N
30°30'N
30°20'N
30°10'N
30°0'N
N
SH1
SH2
SH2B
Shatt al Arab
SH3
SH4
0 4.5 9 18 27 36 Km
WQI 2016
station
river
good
poor
very poor
unsuitable

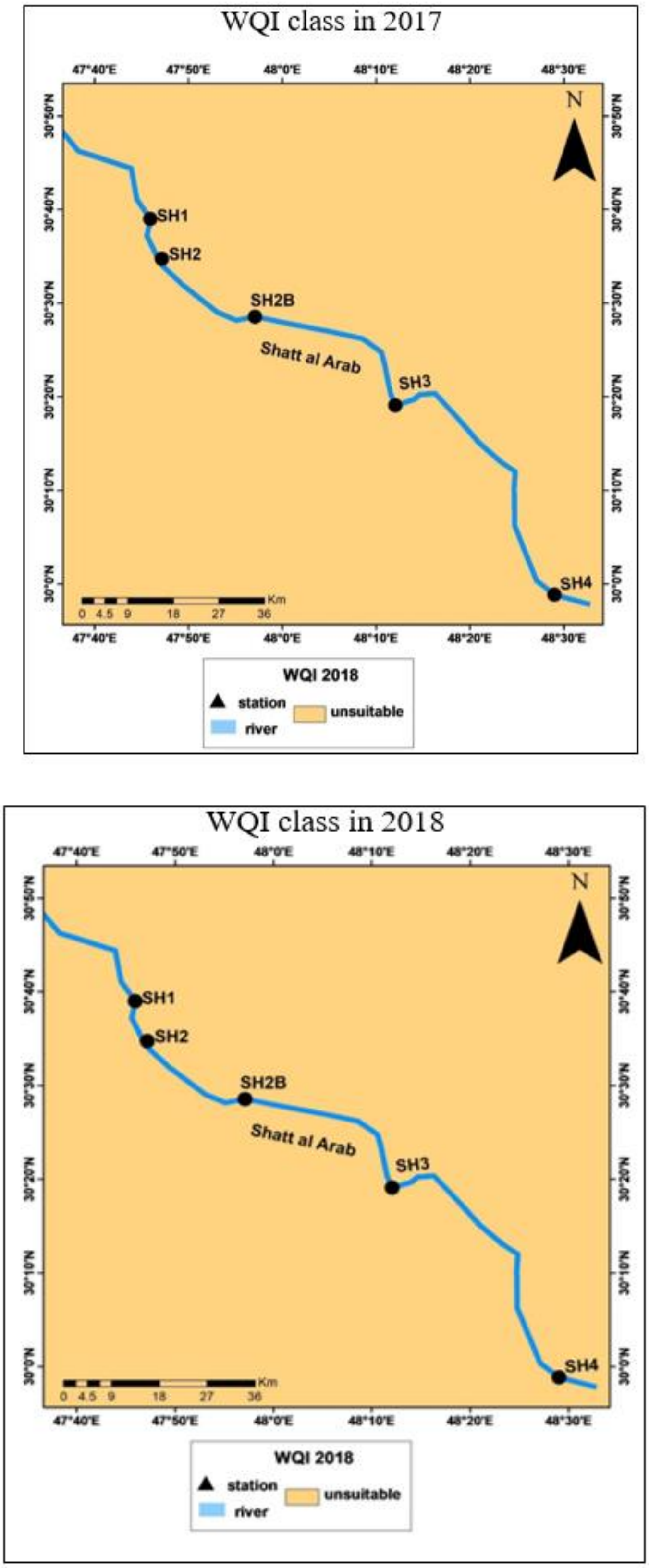


Figure (4): Maps illustrate the classification of water quality along the river.

Conclusion

The WQI has been useful and practical in evaluating water for drinking purposes over a long period of time. The lowest recorded value of WQI was in 2014 indicating the best water quality comparing with the other years, while the quality collapse in 2017 and 2018 indicating unsuitable water for drinking. GIS was a useful tool in water quality analysis and building maps that helped in results explanation. It is noted that the WQI should continue to be calculated for the purpose of evaluating water for different uses.

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