Impact Assessment of Desalination Plants on Kuwait Bay using GIS/Water Quality Index Analysis

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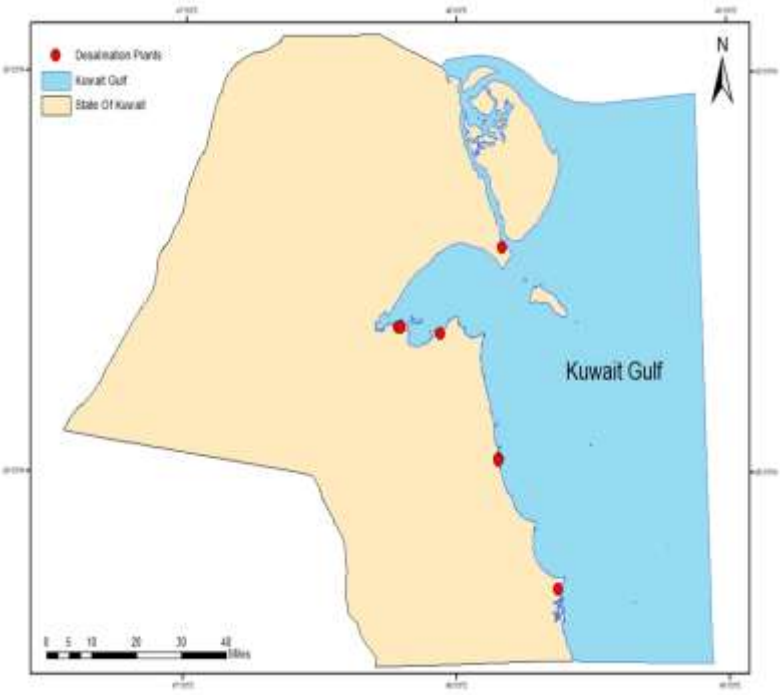
Overview

- Introduction / Objectives
- Material and Methods
- Results and Interpretation
- Discussion and Conclusions
- Recommendations

Introduction

Problem Statement:

- Six Desalination plants are located along the Kuwait Bay which receives the hypersaline brine effluent discharged from such plants.
- The Kuwait bay covers an area of 735 km^2 an has 130 km coastline along the Arabian Gulf.
- The Bay is a semi-enclosed water body that suffers from various pollution loads.



Objectives of the Study:

- This study presents a novel approach, which integrates the water quality index(WQI) with the GIS technology, to assess the impact of desalination plants on Kuwait Bay.

Materials and Methods

- The Study Area
- Geographic Information System(GIS)
- Water Quality Index (WQI)
- Data were obtained from Kuwait Environment Public Authority (KEPA) as collected from 13 stationary monitoring stations and 15 Buoyant stations for the years 2015, 2016, 2017.

Study Area

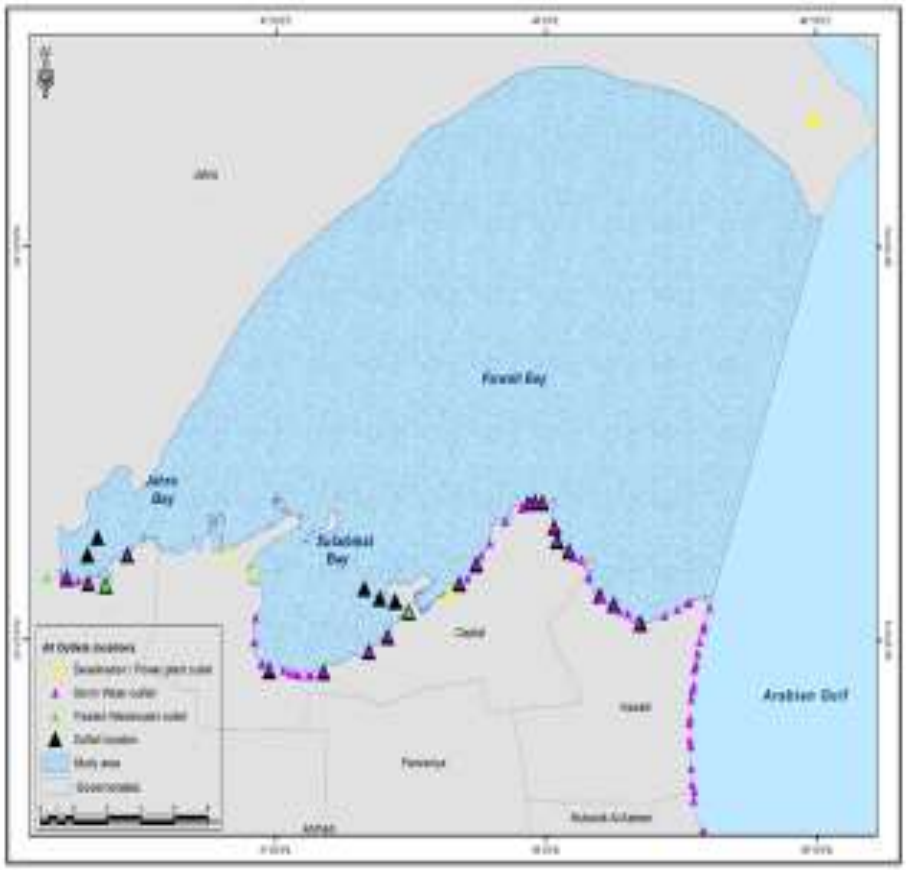
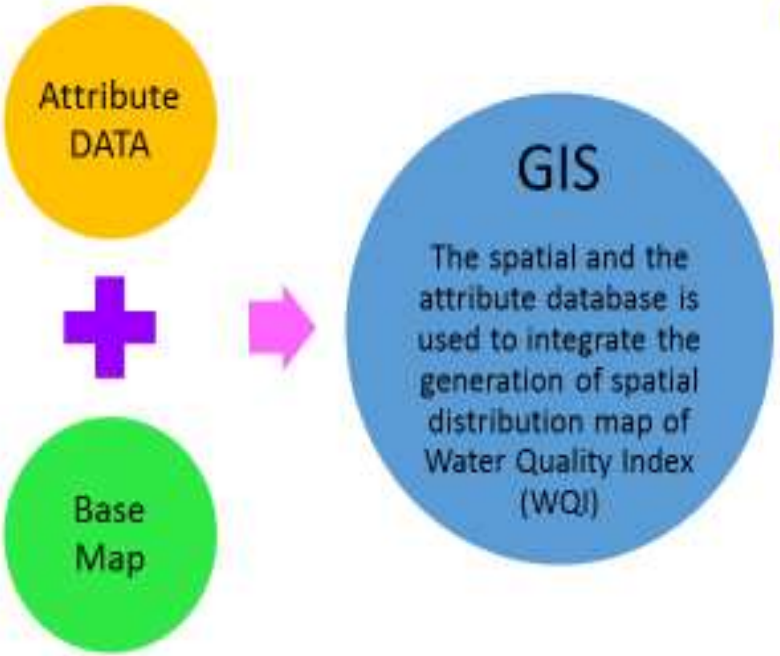


Fig. 1. All Outlets along Kuwait Bay.

Geographic Information System(GIS)



- Data Source: Kuwait Environmental Public Authority
- From year 2014-2017
- 13 Stationary Monitor Stations
- 15 Buoys Station (New)

Weighted Arithmetic Water Quality Index Method

Weighted arithmetic water quality index method classified the water quality according to the degree of purity by using the most commonly measured water quality variables.

The calculation of WQI was made by using the following equation:

$$WQI = \sum Q_i W_i / \sum W_i$$

The quality rating scale (Qi) for each parameter is calculated by using this expression:

$$Q_i = 100[(V_i - V_o)/(S_i - V_o)]$$

Where,

V_i = measured concentration of i^{th} parameter in the analyzed water

V_o = the ideal value of this parameter in pure water.

V_o = 0 (except pH =7.0 and DO = 14.6 mg/l)

S_i s recommended standard value of i^{th} parameter

The unit weight (Wi) for each water quality parameter is calculated by using the following formula:

$$W_i = K/S_i$$

Where,

K = proportionality constant and can also be calculated by using the following equation:

$$K = \frac{1}{\Sigma 1/S_i}$$

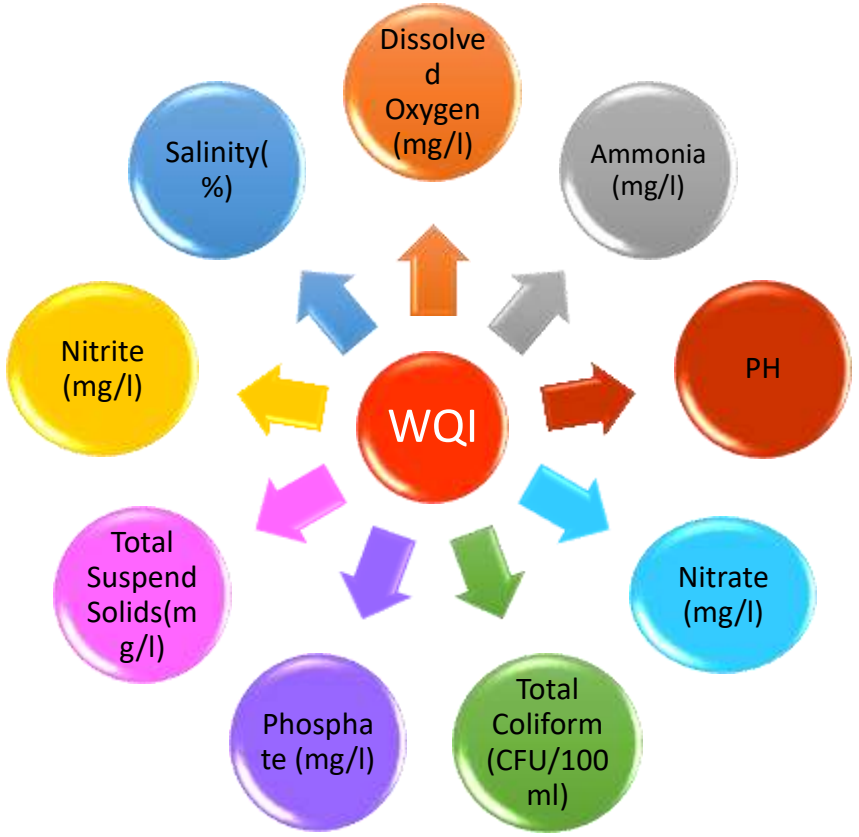
Table 1. Water Quality Rating as per Weight Arithmetic Water Quality Index Method.

WQI Value	**Status**	**Grading**	**Possible Usage**
0-25	Excellent Water Quality	A	Drinking, Irrigation and Industrial
26-50	Good Water Quality	B	Domestic, Irrigation and Industrial
51-75	Fair Water Quality	C	Irrigation and Industrial
76-100	Poor water Quality	D	Irrigation
101-150	Unsuitable for drinking purpose	E	Restricted use for irrigation
Above 150	Unfit for drinking	F	Proper treatment required before use

Results and Interpretation

Table 2. . Water Quality Parameters (Average values from monitoring stations)

Location ID	Station	Ammonia	DO	PH	Nitrate	Nitrite	Phosphate	Total Coliform	TSS	Salinity
Z00	Al-Beda'a	141.22	6.05	7.91		2.735	16.85	0	18500	36.31
Z02	Al-Doha	143.15	3.52	8.68	4.85	3.62	28.125	40	14400	42.15
Z08	Al-Fintas	119.98	6.24	7.95		3.45	23.58	0	9600	36.54
Z09	Al-Mangaf	130.61	6.75	7.97		2.75	26.98	0	10700	36.63
Z07	Al-Messila	120.68	7.95	7.93		3.935	19.44	0	11200	36.21
Z04	Al-Shuwaikh	127.52	3.37	8.61	3.84	4.42	17.165	100	23600	41.71
Z01	Medayrah (Jal Az-Zour)	131.17	3.19	8.57	3.13	3.23	18.96	10	20120	41.81
Z10	Mina Abdulla	127.82	6.07	7.94		3.905	23.73	0	11600	36.55
Z05	Ras Ajuzah	131.94	5.79	7.9		3.68	25.75	0	15400	38.15
Z06	Ras Al-Ard	149.065	5.11	7.87		7.155	22.98	0	15100	37.57
Z03	Ras Ushayrij	201.295	3.12	8.57	3.51	4.54	30.905	20	16000	42



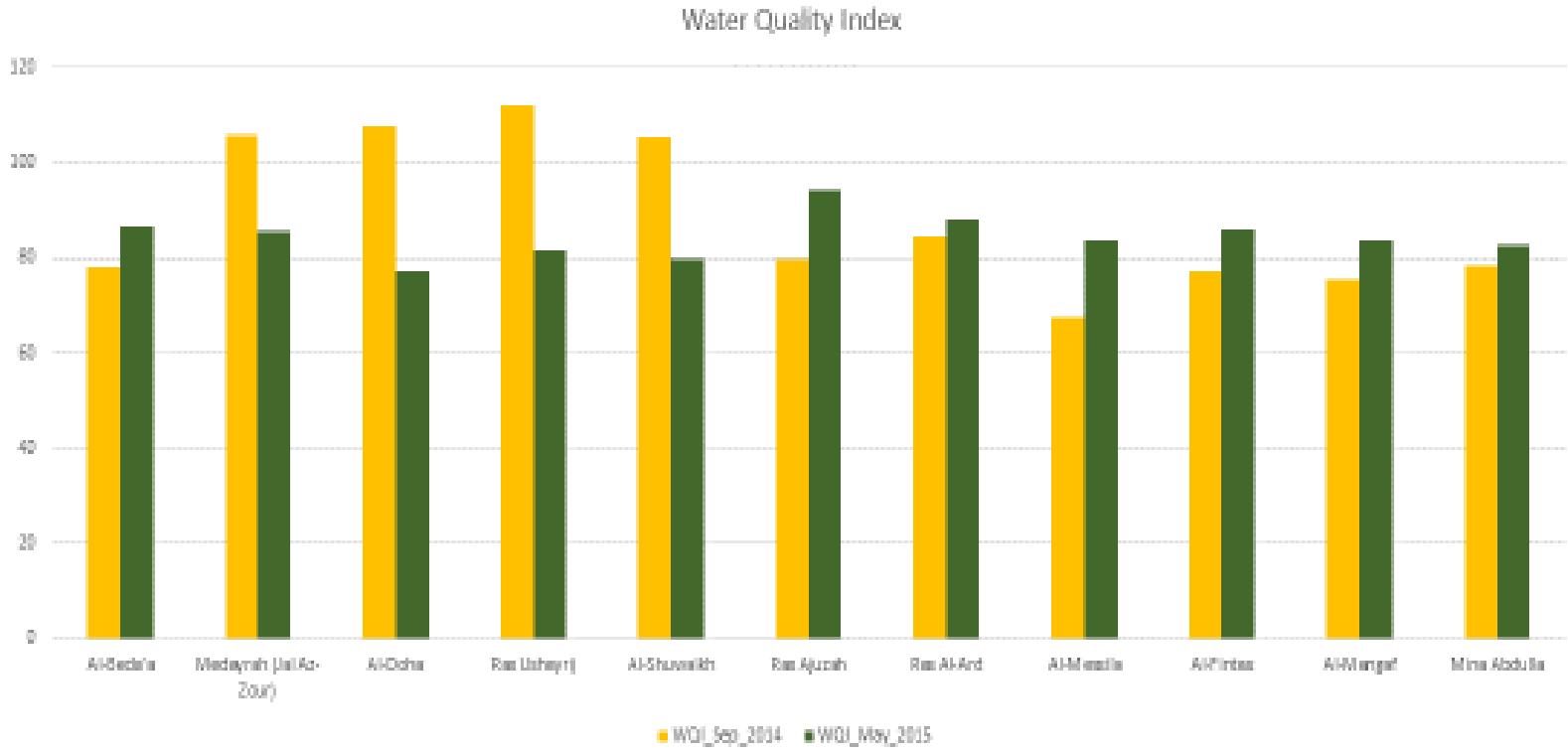


Fig. 2 Comparison between water quality index year 2014 and year 2015

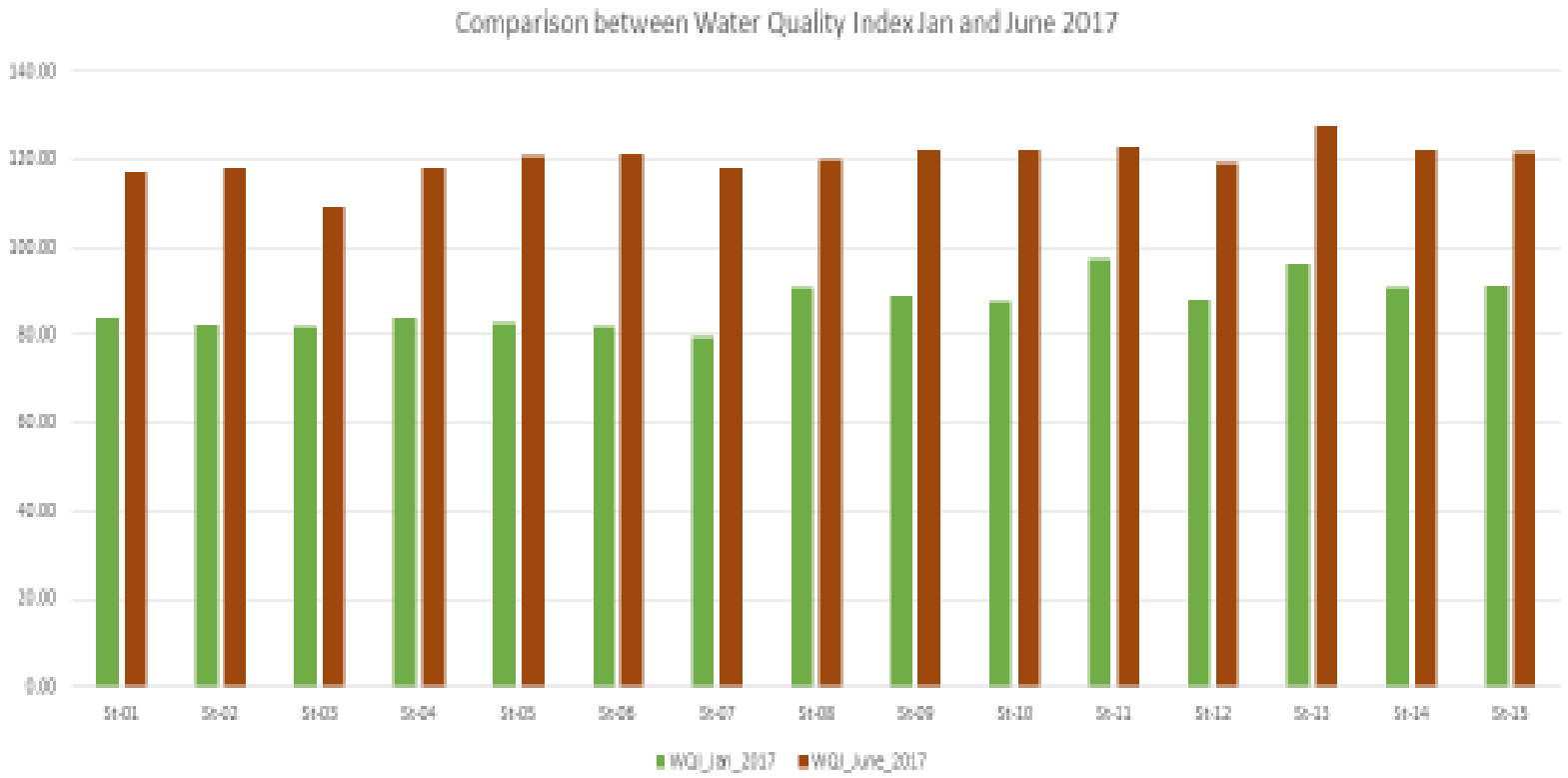


Fig.3 Comparison between water quality index January and June 2017 based on 15 Buoys Stations

Table 3. WQI based on data from stationary and buoyant monitoring stations

Buoys Station Number	WQI_Jan_2017	WQI_June_2017
St-01	83.81	117.24
St-02	82.40	117.87
St-03	81.82	109.17
St-04	84.03	118.17
St-05	82.76	120.89
St-06	81.80	121.11
St-07	79.57	118.17
St-08	90.98	120.14
St-09	88.76	121.97
St-10	87.52	122.06
St-11	97.26	122.70
St-12	88.11	119.04
St-13	95.98	127.70
St-14	90.69	121.99
St-15	83.81	117.24

Name	WQI_Sep_2014	WQI_May_2015
Al-Beda'a	78.0771	86.76192
Medayrah (Jal Az-Zour)	105.8206	85.61359
Al-Doha	107.6095	77.29153
Ras Ushayrij	111.8248	81.68797
Al-Shuwaikh	105.4712	79.75187
Ras Ajuzah	79.78159	94.37651
Ras Al-Ard	84.43719	88.17478
Al-Messila	67.26932	83.72505
Al-Fintas	77.07395	85.87413
Al-Mangaf	75.46737	83.87686
Mina Abdulla	78.41669	82.68312

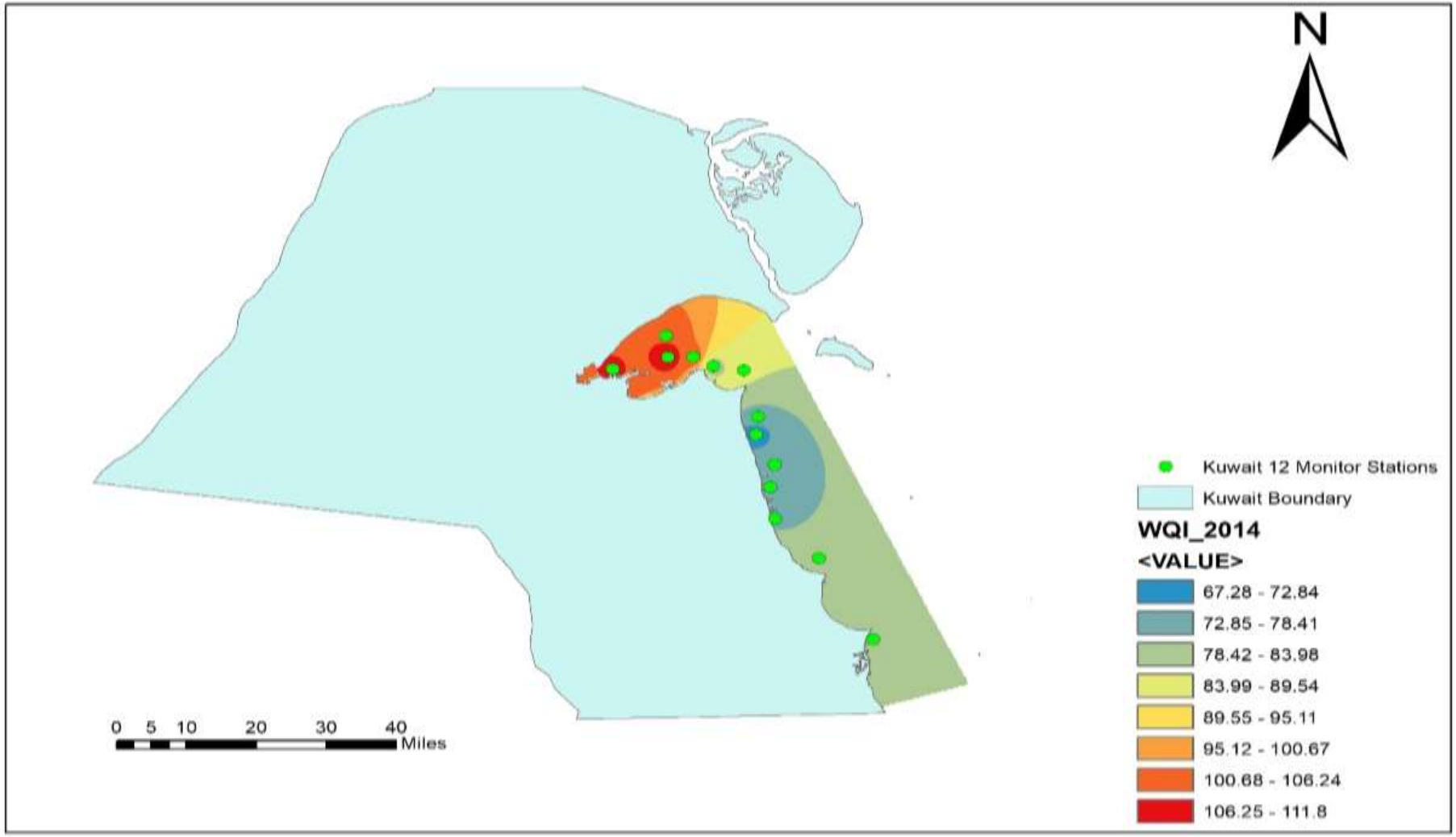


Fig.4 Spatial distribution for Water quality index year 2014 based on 13 monitoring stations

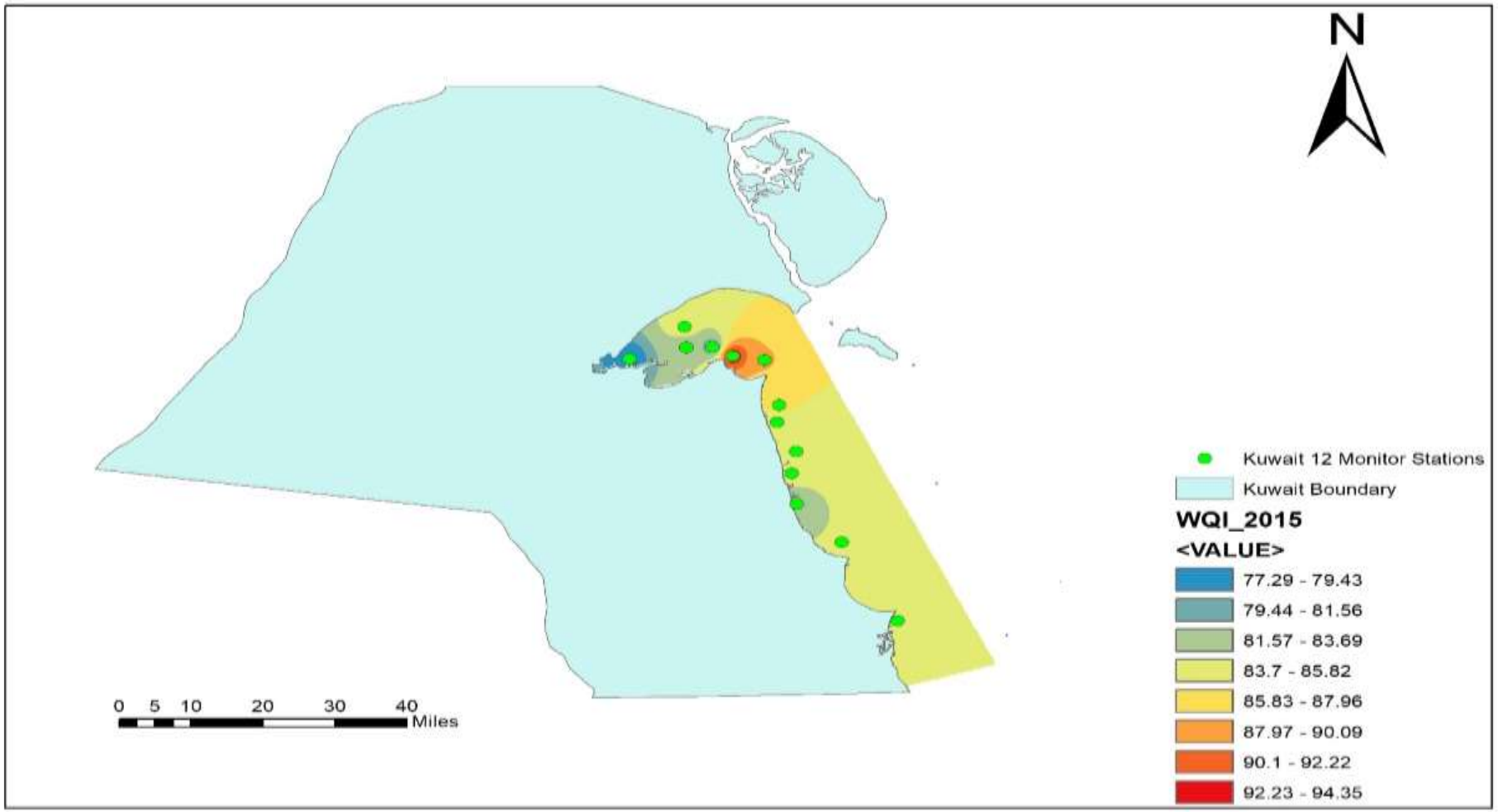


Fig.5 Spatial distribution for Water quality index year 2015 based on 13 monitor stations

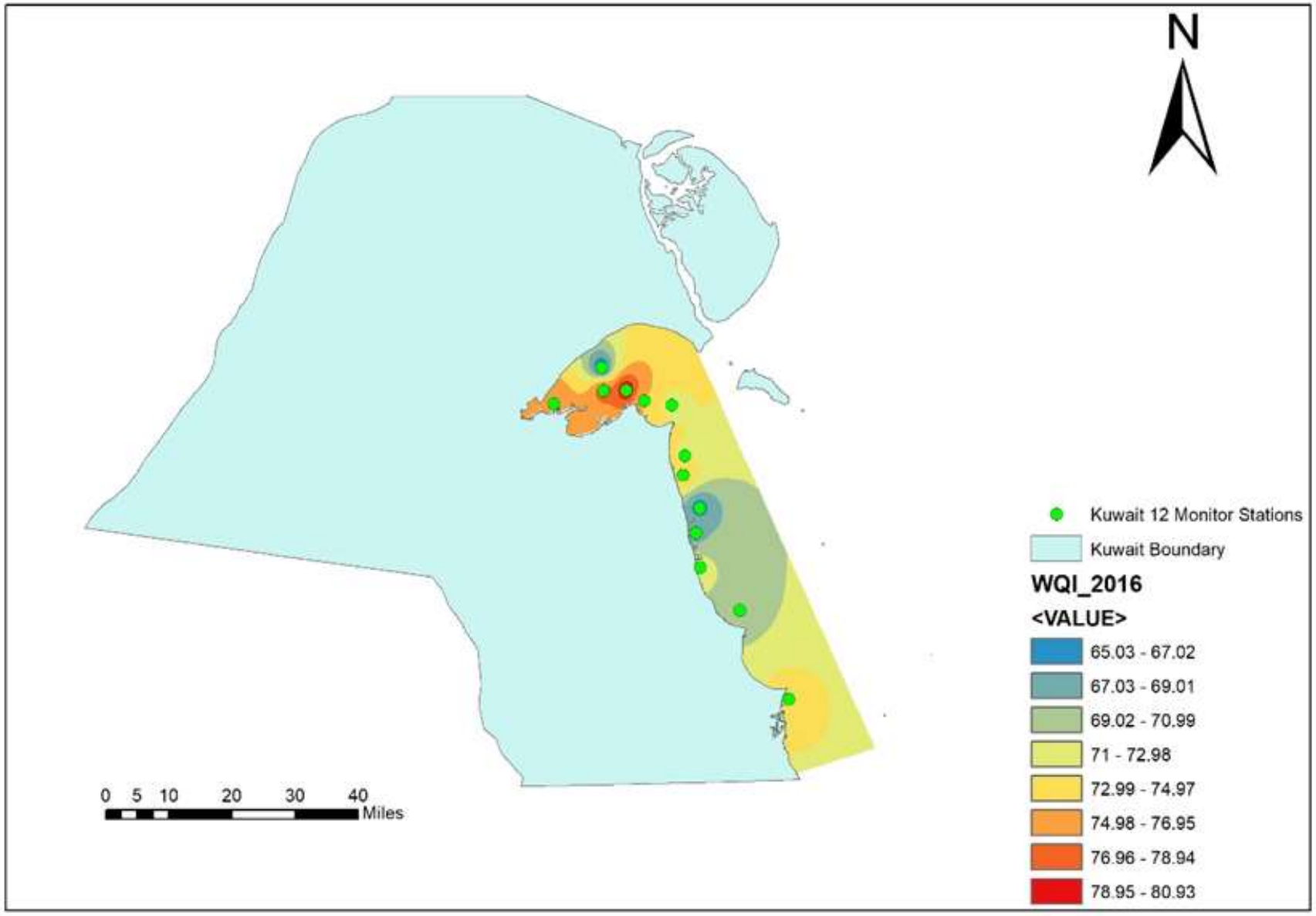


Fig.6 Spatial distribution for Water quality index year 2016 based on 12 monitor stations

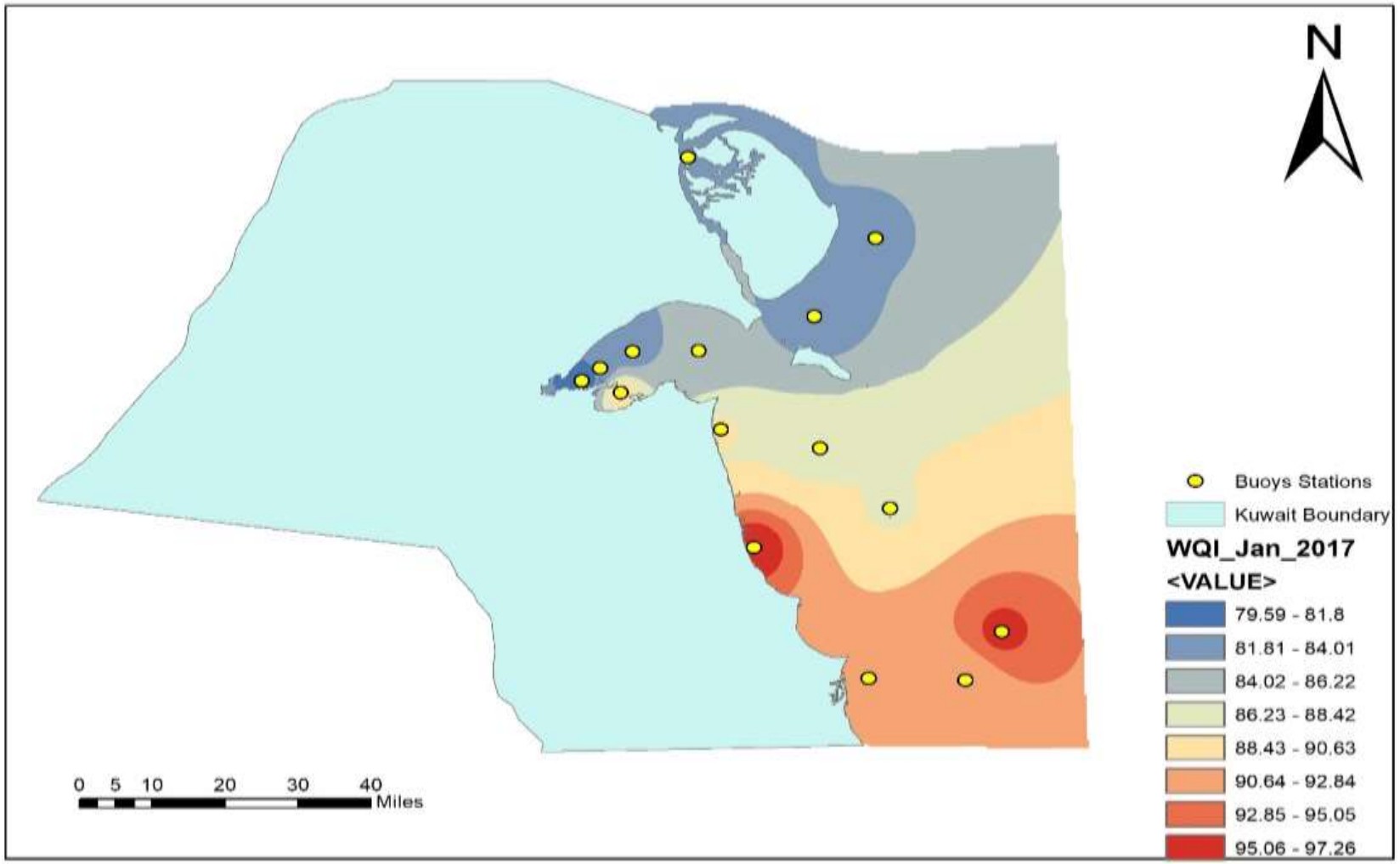


Fig.7 Spatial distribution for Water quality index January 2017 based on 15 Buoys monitor stations

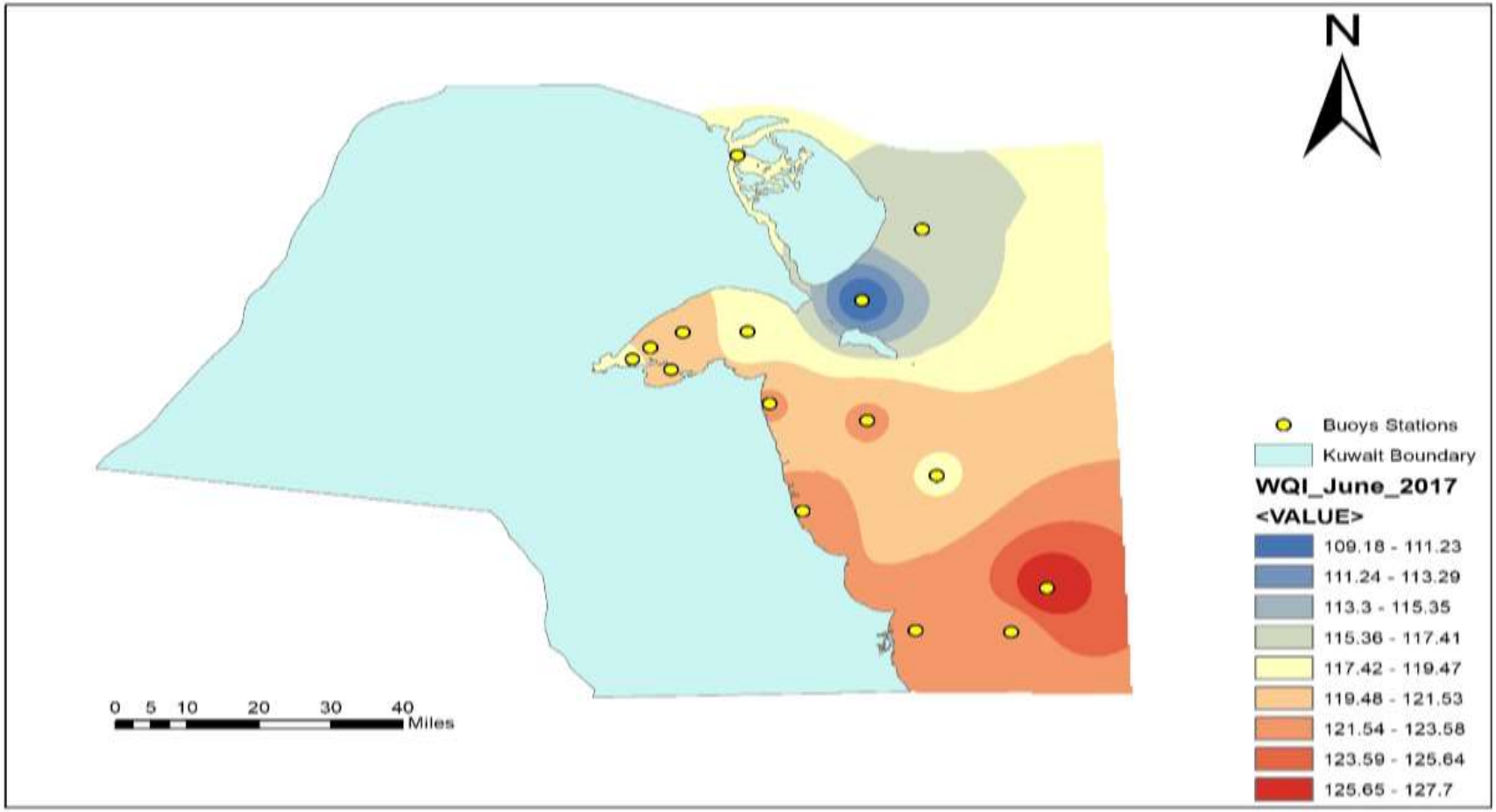


Fig.8 Spatial distribution for Water quality index June 2017 based on 15 Buoys monitor stations.

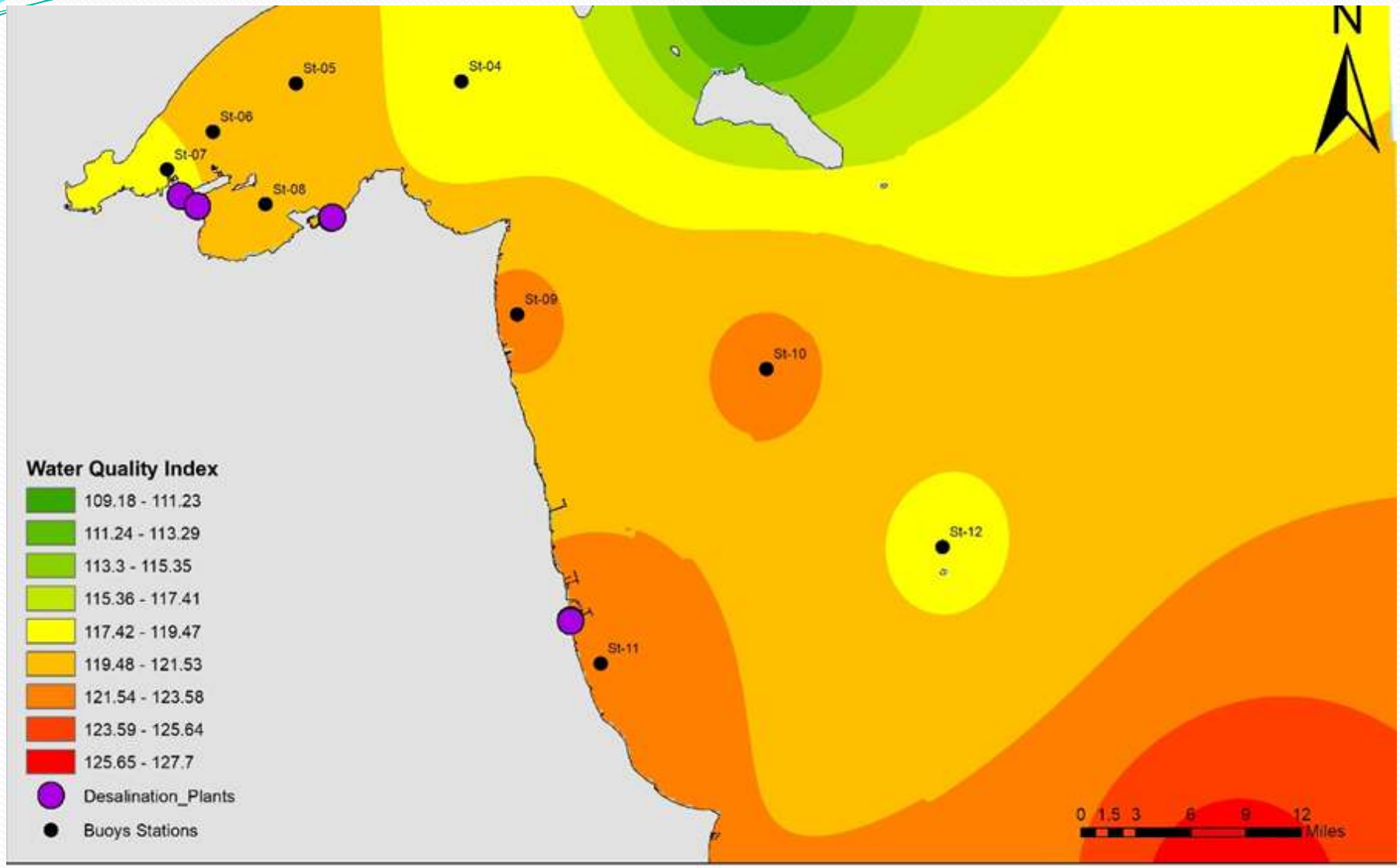


Fig.9 Water quality index near desalination plants showing a score higher than 100 (June 2017)

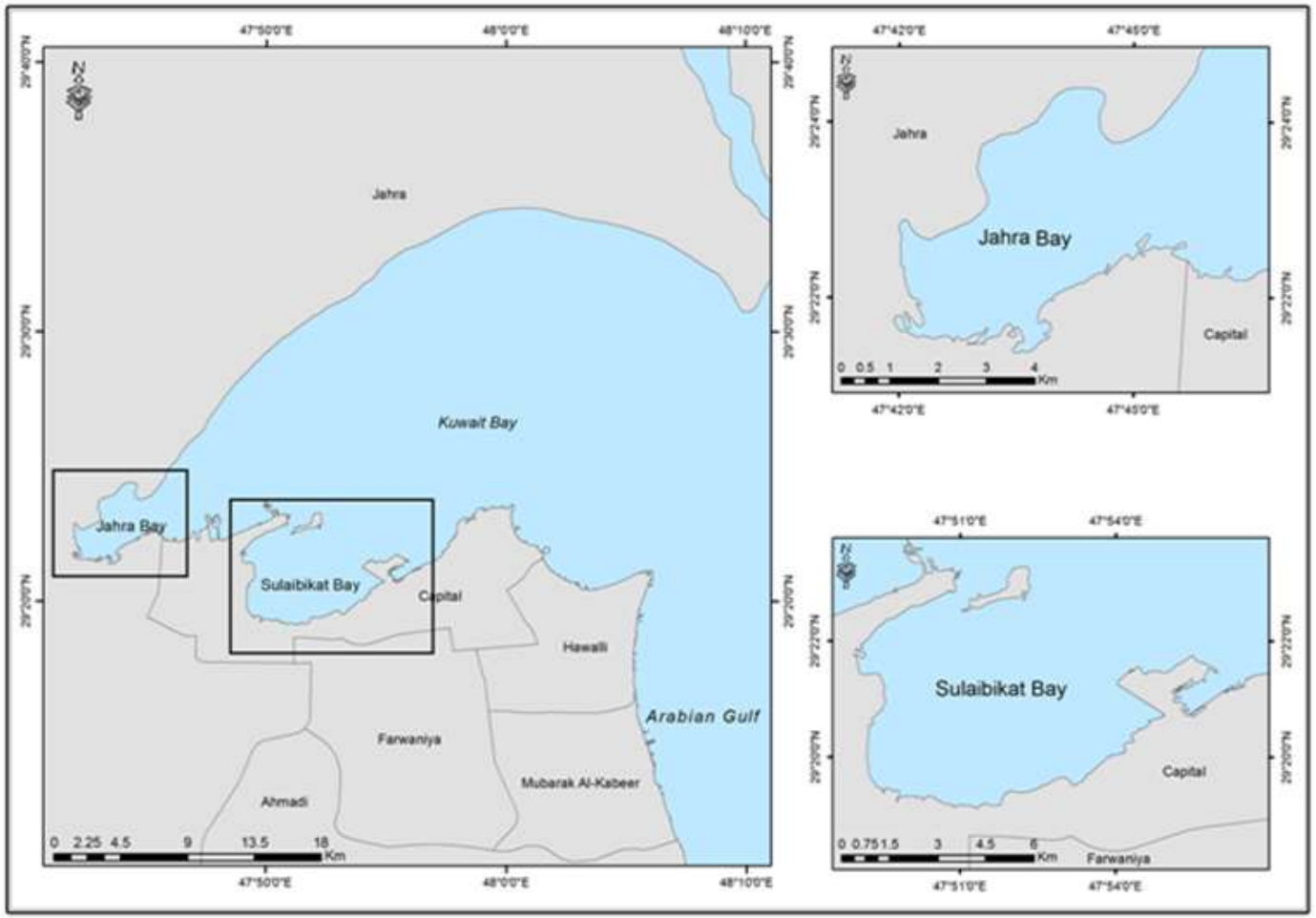


Fig.10 High risk zones in Kuwait Bay

Conclusions

- The WQI scores show very poor to unsuitable quality of water samples in almost all desalination plants along the bay, suggesting that hypersaline brine effluent discharged from such plants must be treated before discharging into the Bay.
- Use of GIS mapping proved to be a useful technique in identifying the most affected areas in the Bay.
- The Sulaibikhat Bay and Jahra Bay are highly affected zone in Kuwait Bay.

Recommendations

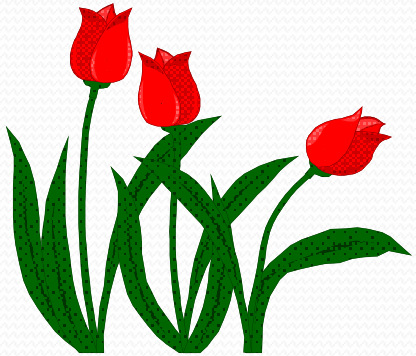
- Desalination plants need to stop discharging the brines or treat the brine before discharging it into the sea since the score of WQI is above 100 in the summer season and status of the water is unsuitable according to the WHO criteria.

Credits and Acknowledgements

The authors would like to thank Engineer Mohamed Al-Enzi, Assistant Director of Kuwait Environment Public Authority, and his staff for providing the data used in this study.

Thank you

Questions ?



Thank you

Questions ?