Using of Nemerow's Pollution Index (NPI) for Water Quality Assessment of Some Basrah Marshes, South of Iraq

Ammar Salman Dawood
Department of Civil Engineering, College of Engineering, University of Basrah
ammars.dawood@yahoo.com

Abstract:

The current research was proposed to evaluate the surface water quality for drinking and irrigation purposes. The study aimed to identify principal pollutants of surface water by using the method named Nemerow's Pollution Index (NPI) in some marshes of Basrah province. The water samples were collected from the monitoring stations and analyzed for thirteen physico-chemical parameters included pH, dissolved oxygen, phosphate, nitrate, calcium, magnesium, total hardness, potassium, sodium, sulphate, chloride, total dissolved solid, and electrical conductivity. Based on data monitored and recorded at five monitoring stations in the study area during cool and hot seasons in 2014, water quality of the marshes was assessed through Nemerow pollution index method. The results are compared with Iraqi and WHO standards. Water analyses presented undesirable values for almost all physico-chemical parameters, according to Iraqi and WHO standard limits for drinking and irrigations. Thus, all sampling stations reported high NPI value and water samples belonged to not clean water.

Key words: Surface water quality, physico-chemical parameters, Nemerow's Pollution Index (NPI), Basrah Marshes

الخلاصة

اقترح البحث الحالي لتقييم نوعية المياه السطحية لأغراض الشرب والري. تهدف الدراسة إلى التعرف على الملوثات الرئيسية للمياه السطحية باستخدام طريقة اسمها مؤشر تلوث نيمرو (NPI) في بعض اهوار محافظة البصرة. تم جمع عينات المياه من محطات المراقبة وتحليلها لثلاثة عشر معلما فيزيائيا وكيميائيا شملت الرقم الهيدروجيني والأكسجين المذاب والفوسفات والنترات والكالسيوم والمغنيسيوم والصلابة الكلية والبوتاسيوم والصوديوم والكبريتات والكلوريد و المواد الصلبة المذابة الكلية والتوصلية الكهربائية. واستنادا إلى البيانات التي تم رصدها وتسجيلها في خمس محطات مراقبة في منطقة الدراسة خلال الموسم البارد و الحار في عام 2014، تم تقييم نوعية المياه في الاهوار من خلال طريقة مؤشر تلوث نيمرو. تمت مقارنة النتائج مع المعايير العراقية ومنظمة الصحة العالمية. قدمت تحليلات المياه قيم غير مرغوب فيها لجميع المعلمات الفيزيائية والكيميائية تقريبا، وفقا للحدود القياسية العراقية ومنظمة الصحة العالمية للشرب والري. وهكذا، أفادت الدراسة الحالية بان جميع محطات أخذ العينات تملك قيم علية من التلوث وكانت عينات المياه تنتمي إلى المياه الغير النظيفة.

الكلمات المفتاحية: نوعية المياه السطحية، المعلمات الفيزيائية والكيميائية، مؤشر تلوث نيميرو، اهوار البصرة

1. Introduction

Water is the fundamental need on the earth for all human beings. As a result of rapid industrialization consequent contamination of sources of both surface water and groundwater, Understanding of contamination and its control, is actually a necessity due to the fact its far-reaching impact on human health. The available source of water may be generally in the form of lakes, groundwater, glaciers, rain water, rivers, etc. Aside from the need of water for consuming such as drinking, the resources of water are likely involved is important in several sectors such as industrial activities, livestock production agriculture, hydro-power generation, fisheries, and other effective activities.

Marshes in Southwest Asia, are one of the biggest wetlands and covered more than 15,000 km^2 **(Richardson *et.al.*, 2006)**. To begin covering with the significant parts of the Mesopotamian Plain, Tigris and Euphrates Rivers were developed **(Buringh, 1960)**. Iraqi marshes are essential as they have actually economic and biodiversity worth. The Marshes and their particular inhabitants have actually observed three wars. And

additionally, the marshes were subjected to drying process through the early 1980s, concerning large drainage works furthermore upstream damming. Finally, in 1991, the marshes were almost totally dried **(UNEP, 2003)**. The effects of drying operations on marshes have resulted in extreme changes in the environment of marshes, these effects included dryness of land, migration of the local people, increasing of Sabkha soils, and degradation of plants and animals **(Jabbar *et.al.*, 2010)**.

For the evaluation of water quality, many indices have actually already been developed. In the current work, Nemerow's Pollution Index (NPI) has been used for the assessment of the current status of water quality for marshes, and to determine the physico-chemical parameters which causes the pollution of water. Nemerow's pollution index (NPI) is an easy pollution index that introduced by Neme **(Rathod *et.al.*, 2011)**. As a result of evaluating and calculating the NPI values of a given water quality parameters, major pollutants of the given water quality parameters can be determined. Thus the use of NPI is advantageous for offering quick and simple assessment result of the status of water quality.

One of the most important environmental problems in Basrah province is the increase in salinity of the surface water as well as the contamination. Few scientific studies have used new approaches to analyze the potential sources of contamination and its effect in aquatic life of the marshes in Basrah province. Hence, the purpose of the study is to study the contaminant levels and its sources in water of the marsh, to be able to assess their environmental influences on the aquatic life.

Pollution index is regarded one of the effective tools to analyze and convey data (raw environmental information) to public, technicians, managers, and decision makers **(Caeiro *et.al.*, 2005)**. The aim of this study is to assess the NPI value for surface water in the marshes of Basrah province. Investigating this result, assessment technique of NPI, which combine average value of pollutants with that of maximum value. NPI in this research used the 2013-2014 monitoring data to assess and qualify the water quality condition of the marshes.

2. Experimental methods:

2.1. Samples of study area:

The water samples in the study area were collected from some water of marshes during two seasons (cool and hot). Five water samples were taken from the marshes in December 2013 to February 2014 (represents cool season) and another five water samples were collected in June 2014 to September 2014 (represents hot season). The study area, including five monitoring stations monitored by Basrah environment directorate, located in Basrah province as shown and represented in Figure (1).

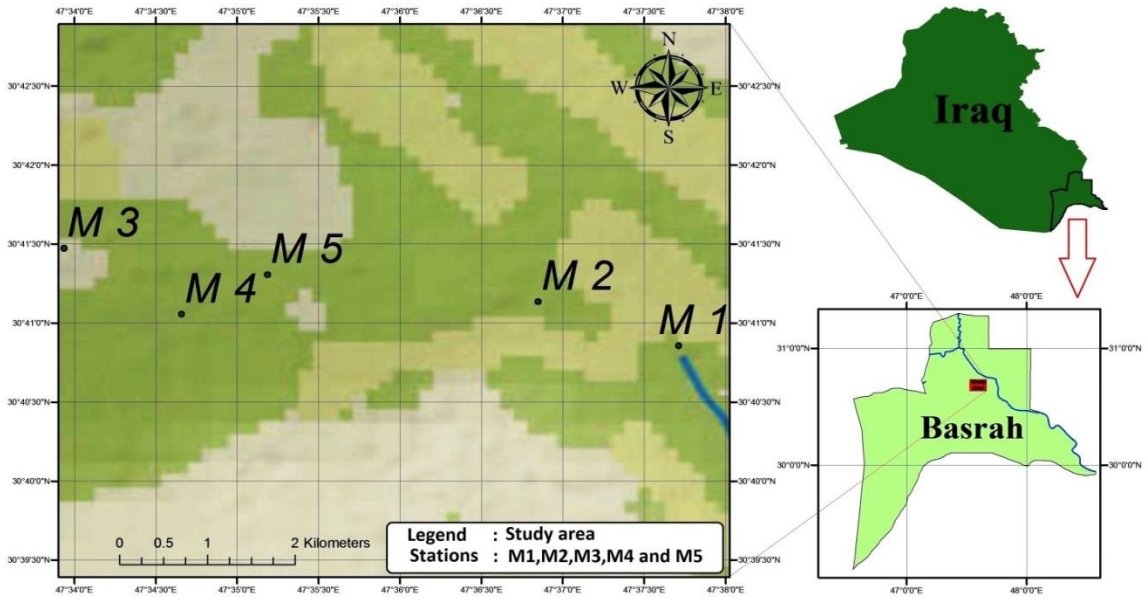


Figure (1): Map of the study area

2.2. Physico-chemical analysis:

Water samples in the study area were examined by Basrah environment directorate, for the following physico-chemical parameters; pH, Dissolved Oxygen (DO), Electrical Conductivity (EC), and Total Dissolved Solids (TDS) of water from marshes was measured in the situ with a different meter devices, that has been previously calibrated, whereas the other physico-chemical parameters of the water samples were examined in the lab of environment at Basrah environment directorate, according to the standard methods.

2.3. Correlation matrix

The correlation analysis can be used to determine the relationships that exist between the physico-chemical characteristics of water samples. These relationships can expose the solutes origin and the process that created the water that is certainly observed **(Azaza *et.al.*, 2011; Parizi and Samani,2013)**. The correlation analysis result is regarded in the succeeding interpretation. A good positive relationship between two variables be high, when its correlation coefficient (near 1 or 1). There is no relationship between two variables when the correlation coefficient around zero. The relationship between two variables measured at a significance level of $p < 0.05$. Much more properly, it can be stated that parameters showing correlation coefficient of more than 0.7 are regarded as strongly correlated, but when the correlation coefficient is between 0.5 and 0.7, the relationship indicates moderate correlation **(Manish *et.al.*, 2006)**.

2.4. Nemerow's Pollution Index (NPI):

The Nemerow pollution index (NPI) denote to the pollution computing, which developed by **(Nemerow and Sumitomo, 1971)**. The NPI is given as one of the simplified pollution index and it can be determined by the following equation:

$$NPI = \frac{C_i}{L_i} \qquad \text{.....(1)}$$

Where, C_i- is the revealed concentration of i^{th} parameter, and L_i is the allowable limit of i^{th} parameter.

In equation (1) above, the unit of C_i and L_i must be the same unit. The value of NPI represents the general pollution provided by a single parameter. NPI has no units. L_i values for different water quality parameters and uses are shown in Table (1). When the value of NPI exceeding 1.0, indicate the presence of impurity in the water and accordingly need to have some treatment prior to use.

Table (1): Standard values of water quality parameters (Standard specification no. 417, 2009) and (WHO, 2011)

PARAMETER	Unit	Drinking		Irrigation	
		Iraqi	WHO	Iraqi	WHO
pH	-	8.5	8.5	8.6	8.5
DO	mg/L	5	5	5	-
PO_4	mg/L	-	-	25	-
NO_3	mg/L	10	45	50	-
Ca	mg/L	200	75	450	20
Mg	mg/L	150	50	80	50
TH	mg/L	500	500	300	-
K	mg/L	12	12	100	2
Na	mg/L	200	200	-	4
SO_4	mg/L	400	250	200	20
Cl	mg/L	200	250	250	300
TDS	mg/L	1500	500	2500	2000
EC	µs/cm	2000	1000	250	2000

3. Results and discussion:

The data of physico-chemical properties for cool and hot seasons are shown in Figure (2). The results indicate that the average values of almost studied physico-chemical parameters are above the maximum permissible limits state by Iraqi and WHO standards for using water for drinking and irrigation. Statistical parameters for water samples in the study area in both seasons are tabulated in Tables (2) and (3).

The noticed values for pH of water samples in the cool season are ranged between 8.6 and 8.8. Whereas, the pH values in the water samples in the hot season are varied from 8.03 to 8.15. This may be related to the activities from anthropogenic, which include the disposal of sewage, incorrect irrigation process, and the weathering process in the area. Dissolved oxygen recorded the extreme value 8.96 mg/L, while the least value was noticed to be 9.38 mg/L in the cool season. While the extreme value of 6.89 mg/L and the least value of 7.47 was found in hot season.

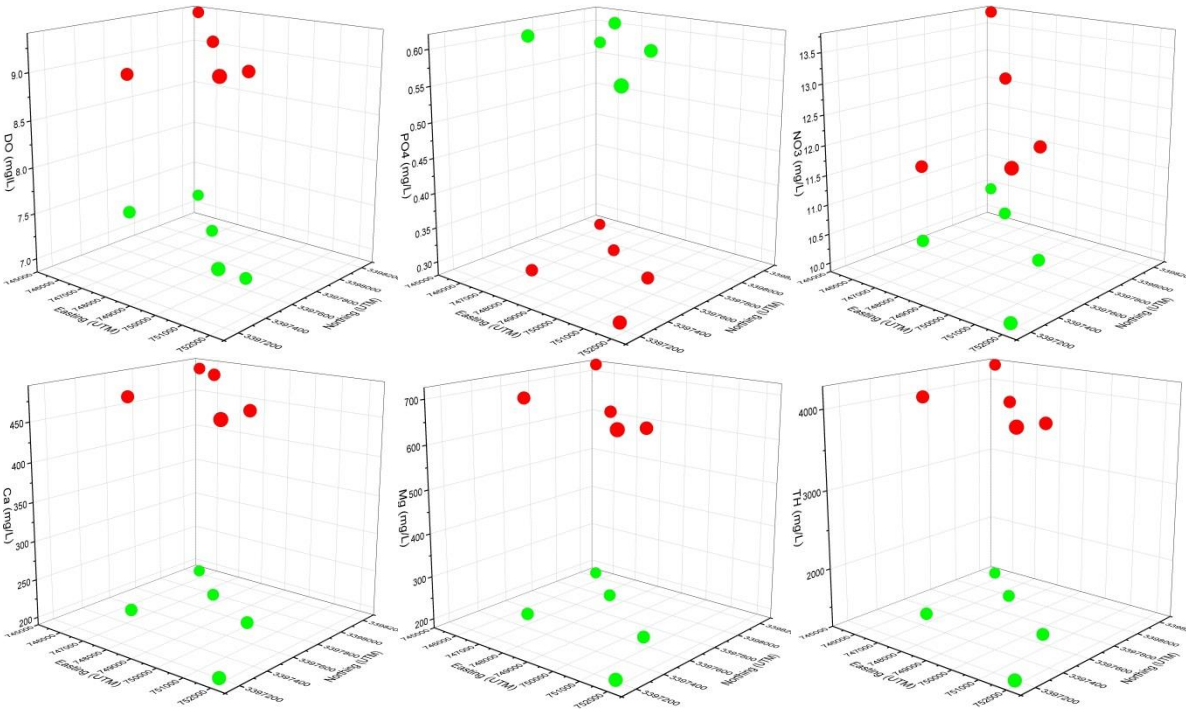
Phosphate concentration displayed the highest value 0.29 mg/L and the lowest value of 0.28 mg/ L was observed during the cool season in the study area. The average value of cool season was found as 0.285 mg/L. The minimum value and maximum value of phosphate in hot season was observed to be 0.57 and 0.62 mg/L, respectively. The average value of hot season was found as 0.60 mg/L.

The most and popular contaminants in environments is nitrogen compounds, which is basically coming from the agricultural sources. Many diseases like methemoglobinemia , diabetes, and thyroid disease are strongly associated with the exposure of nitrate-nitrogen **(Krishna *et.al.*, 2011)**. For this reason, raising nitrogen contamination severely jeopardise human health and public drinking water supply. The value of nitrate in the water samples is observed between 11.59 and 13.78 mg/L with an

average value of 12.51 mg/L in the cool season. Whereas, highest nitrate concentration is found to be 10.49 mg/L during the hot season of this study followed by lowest value of 9.89 mg/L. The average value of hot season was found to be 10.27 mg/L. All water samples are not exceeding the allowable limitation of 45 mg/l as per WHO standard, but some water samples are exceeding the permissible limit of 10 mg/l as per Iraqi standard for drinking water.

Hardness of the water is related to the existing of calcium and magnesium ions. The concentrations of calcium and magnesium in waters are commonly used to categorize the suitability of water. The concentration of calcium in the study area, is ranged between 470.33 and 493.67 mg/L during the cool season, and its concentration is varied between 191.25 and 205.5 mg/L in the hot season. The highest concentration of calcium ions in water can cause conditions which can be abdominal and is unsuitable for domestic purposes because it causes scaling and encrustation.

The concentration of magnesium is varied from 644 to 725 mg/L in the cool season, while its concentration is changed between 179 mg/L to 200 mg/L in the hot season of the study area. The maximum value of total hardness in the water samples was (4252.67 mg/L), whereas the minimum value was 3898 mg/L that was recorded during the cool season of the study. While, the minimum recorded value of 1246.25 mg/L was found and the maximum value of (1344.5 mg/L) was found for total hardness in the hot season of the study area.



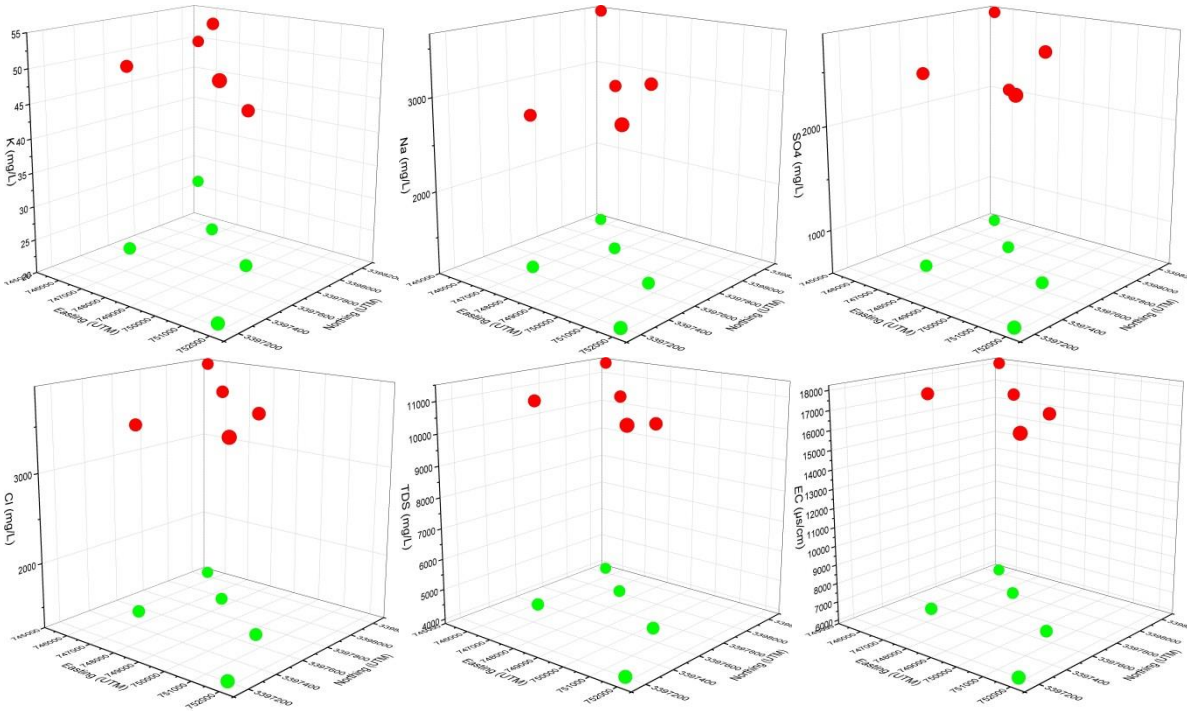


Figure (2): Physico-chemical properties of water samples in cool and hot seasons (Red ball of Cool season and Green ball of Hot season)

The concentration of sodium in the study area is varied from 2785 to 3650 mg/L in the cool season, although it is varied between 1095 and 1140 mg/L in the hot season. The average value of potassium concentration is 50.4 mg/L in the cool season, and the average value of 23.2 mg/L was recorded during the hot season, which reveal that from the study conditions, the potassium is complexes and it is one of the naturally occurring elements. From the recorded values of potassium, its concentration continues to be quite lower compared with calcium, magnesium, and sodium.

Table (2): Minimum, Maximum, Average, and Standard Deviation characteristics of physical-chemical parameters in the cool season in the study area

PARAMETER	Min.	Max.	Ave.	SD.
pH	8.60	8.80	8.67	0.08
DO	8.96	9.38	9.17	0.16
PO_4	0.28	0.29	0.28	0.01
NO_3	11.59	13.78	12.51	0.84
Ca	470.33	493.67	482.73	8.87
Mg	644.00	725.00	682.27	34.48
TH	3898.00	4252.67	4065.07	147.18
K	45.00	54.67	50.40	3.59
Na	2785.00	3650.00	3133.00	326.24
SO_4	2200.00	2833.33	2560.00	246.53
Cl	3494.00	3915.50	3709.00	150.14
TDS	10494.00	11471.00	10961.60	366.95
EC	17113.33	18203.33	17504.67	458.06

Table (3): Minimum, Maximum, Average, and Standard Deviation characteristics of physical-chemical parameters in the hot season in the study area

PARAMETER	Min.	Max.	Ave.	SD.
pH	8.03	8.15	8.07	0.05
DO	6.89	7.47	7.20	0.25
PO_4	0.57	0.62	0.60	0.02
NO_3	9.89	10.49	10.27	0.24
Ca	191.25	205.50	198.60	5.88
Mg	179.00	200.00	190.05	8.95
TH	1246.25	1344.50	1290.55	40.91
K	20.50	27.00	23.20	2.36
Na	1095.00	1140.00	1109.00	19.17
SO_4	575.00	600.00	587.50	12.50
Cl	1273.25	1394.50	1317.40	46.40
TDS	3881.50	4339.50	4082.60	169.27
EC	5815.00	6360.00	6050.50	212.60

When the concentration of sulphate in water has exceeded the maximum allowable limit of 400 mg/L, it is probable to react with human organs and causes a laxative result on the human system. The concentration of sulphate in the cool season is observed from 2200 to 2833.33 mg/L, and it is recorded between 575 to 600 mg/L in the hot season. Nevertheless, the sulphate concentration in water samples of the study area is not within the maximum allowable limit as per WHO and Iraqi standards.

The range of chloride of water samples in the cool season, is observed to vary between 3494 and 3915.5 mg/L, and its concentration is found to be between 1273.25 and 1394.5 mg/L in the hot season. In the study area, the chloride concentration is exceeds the maximum allowable limit as per the WHO and Iraqi standards.

The value of total dissolved solids, in the water samples of the study area, is varied between 10494 and 11471 mg/L in the cool season and it was between 3881.50 and 4339.50 mg/L in the hot season. The occurrence of high TDS detected in the study area is due to the impact of anthropogenic sources, including agricultural activities and domestic sewage. The TDS values in the study area are more than the highest desirable value (500 mg/L) and also more than the maximum permissible values stated by Iraqi standards and WHO specification.

The most desired limit of electrical conductivity in drinking water is suggested as 1,500 µS/cm. The maximum value of electrical conductivity in water samples was found to be 18203.33 µS/cm and the minimum value was 17113.33 µS/cm was noticed in water samples during the cool season. The average value of cool season was found as 17504.67 µS/cm. Meanwhile, the value of electrical conductivity in the study area is between 5815.00 and 6360.00 µS/cm in hot season.

The correlation matrices for pH, DO, PO_4, NO_3,TH, TDS, EC, and major ions were prepared and explained for both cool and hot seasons (Tables (4) and (5)). EC and TDS show high positive correlation with pH, Mg, and TH in the cool season, and shows positive correlation with pH, Mg, TH, SO_4, and Cl in the hot season. In addition, Cl shows high positive correlation with DO, NO_3, and Na in the cool season, and shows positive correlation with pH, Mg, TH, and SO_4 in the hot season. Furthermore, SO_4 shows high positive correlation with Na in the cool season, and shows positive

correlation with pH, NO_3, Mg, TH, K, and Na during the hot season. In addition, PO_4 shows negative moderate correlation with pH in the cool season. Additionally, in the cool season, pH shows moderate positive correlation with NO_3 and Na, and show a moderate negative correlation with PO_4. Ca show moderate negative correlation with SO_4 in the cool season, and show a high positive correlation with K. For both cool and hot seasons, some groups of species show strong correlation ($r > 0.7$), e.g., Mg-TH and NO_3-Na. Whereas, in the hot season, NO_3 show moderate positive correlation with Mg, TH, and Na. During the hot season, PO_4 show moderate positive correlation with Ca and TH, and show a negative moderate correlation with K and Na. Thus, this scenario is being supposed that coincident in rise/reduction in the cations is the effect mostly of dissolution/precipitation reaction and concentration effects.

The standard values of water quality parameters to use water for drinking or irrigation that mentioned in Table 1 are considered for determining the NPI values using the NPI method. The L_i values for various water quality parameters are shown in Table (1). When the value of NPI exceeding 1.0, suggest the presence of impurity in the water sample and therefore need some treatment before using it for drinking or irrigation. The pollution creating parameters as per Nemerow's Pollution Index (NPI) at each station is determined and presented in Tables (6) and (7). These tables demonstrate the results of NPI of the studied parameters in the study area for cool and hot seasons.

Table (4): Correlation matrix of Physico-chemical parameters in cool season

Parameter	pH	DO	PO_4	NO_3	Ca	Mg	TH	K	Na	SO_4	Cl	TDS	EC
pH	1												
DO	0.362	1											
PO_4	-0.612	-0.056	1										
NO_3	0.534	.896*	-0.371	1									
Ca	0.057	0.587	-0.487	0.559	1								
Mg	0.82	0.41	-0.267	0.316	0.071	1							
TH	0.821	0.481	-0.35	0.393	0.217	.989**	1						
K	-0.094	0.336	-0.442	0.255	.942*	0.027	0.164	1					
Na	0.588	0.786	-0.001	0.829	0.04	0.445	0.44	-0.273	1				
SO_4	0.514	0.332	0.333	0.283	-0.541	0.542	0.446	-0.716	0.763	1			
Cl	0.369	.918*	-0.071	.951*	0.403	0.215	0.266	0.083	.900*	0.425	1		
TDS	0.769	0.691	-0.387	0.6	0.452	.910*	.957*	0.345	0.535	0.355	0.474	1	
EC	.990**	0.387	-0.604	0.51	0.121	.881*	.888*	-0.004	0.543	0.476	0.337	0.838	1

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed).

Table (5): Correlation matrix of Physico-chemical parameters in hot season

Parameter	pH	DO	PO_4	NO_3	Ca	Mg	TH	K	Na	SO_4	Cl	TDS	EC
pH	1												
DO	0.572	1											
PO_4	0.189	-0.129	1										
NO_3	0.359	-0.375	0.064	1									
Ca	0.341	-0.397	0.626	0.282	1								
Mg	0.709	0.397	0.405	0.565	0.054	1							
TH	0.771	0.226	0.595	0.613	0.404	.935*	1						
K	0.336	-0.2	-0.498	0.806	0.027	0.238	0.223	1					

Na	0.546	0.199	-0.596	0.611	-0.129	0.327	0.25	.917*	1				
SO_4	0.834	0.344	-0.115	0.718	0.085	0.754	0.72	0.741	0.848	1			
Cl	.974**	0.431	0.382	0.44	0.489	0.759	0.87	0.289	0.432	0.795	1		
TDS	0.859	0.216	0.592	0.554	0.596	0.813	.956*	0.234	0.276	0.713	.951*	1	
EC	0.854	0.276	0.548	0.59	0.46	.900*	.987**	0.262	0.318	0.764	.936*	.985**	1

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed).

The NPI values of pH in the study area, for both seasons and for all monitoring stations, are in permissible range for using water samples for drinking and irrigations, as per Iraqi and WHO standards (see Table (6) and Table (7), Figure (3) and Figure (4)). The NPI values for DO concentration varies from 1.79 to 1.88 in the cool season, whereas it ranges between 1.38 to 1.49 in the hot season, at all monitoring stations. Thus, the NPI values of DO indicate that the water samples in the study area are not suitable for drinking and irrigations according to Iraqi and WHO standards.

Table (6): NPI values of Physico-chemical parameters in the cool season

	NPI values											
Iraqi standard for Drinking	Samples	PH	DO	NO_3	Ca	Mg	TH	K	Na	SO_4	Cl	TDS	EC
	M1	1.01	1.85	1.23	2.43	4.63	8.24	4.36	15.33	6.42	18.49	7.41	8.65
	M2	1.01	1.81	1.21	2.35	4.33	7.80	3.75	16.00	6.83	18.49	7.00	8.56
	M3	1.04	1.88	1.38	2.43	4.83	8.51	4.17	18.25	7.08	19.58	7.65	9.10
	M4	1.02	1.79	1.16	2.39	4.65	8.24	4.17	13.93	6.17	17.47	7.30	8.87
	M5	1.02	1.84	1.29	2.47	4.29	7.87	4.56	14.83	5.50	18.71	7.18	8.59
	NPI values												
WHO standard for Drinking water	Samples	PH	DO	NO_3	Ca	Mg	TH	K	Na	SO_4	Cl	TDS	EC
	M1	1.01	1.85	0.27	6.48	13.89	8.24	4.36	15.33	10.27	14.79	22.24	17.29
	M2	1.01	1.81	0.27	6.27	12.99	7.80	3.75	16.00	10.93	14.79	20.99	17.11
	M3	1.04	1.88	0.31	6.48	14.50	8.51	4.17	18.25	11.33	15.66	22.94	18.20
	M4	1.02	1.79	0.26	6.37	13.96	8.24	4.17	13.93	9.87	13.98	21.91	17.73
	M5	1.02	1.84	0.29	6.58	12.88	7.87	4.56	14.83	8.80	14.96	21.54	17.19
	NPI values												
Iraqi standard for Irrigation water	Samples	PH	DO	NO_3	Ca	Mg	TH	K	Na	SO_4	Cl	TDS	EC
	M1	1.00	1.85	0.01	0.25	1.08	8.68	13.73	0.52	12.83	14.79	4.45	69.16
	M2	1.00	1.81	0.01	0.24	1.05	8.12	12.99	0.45	13.67	14.79	4.20	68.45
	M3	1.02	1.88	0.01	0.28	1.08	9.06	14.18	0.50	14.17	15.66	4.59	72.81
	M4	1.01	1.79	0.01	0.23	1.06	8.73	13.74	0.50	12.33	13.98	4.38	70.92
	M5	1.00	1.84	0.01	0.26	1.10	8.05	13.11	0.55	11.00	14.96	4.31	68.75

	NPI values									
WHO standard for Irrigation water	Samples	PH	Ca	Mg	K	Na	SO_4	Cl	TDS	EC
	M1	1.01	24.28	13.89	26.17	766.25	128.33	12.32	5.56	8.65
	M2	1.01	23.52	12.99	22.50	800.00	136.67	12.33	5.25	8.56
	M3	1.04	24.30	14.50	25.00	912.50	141.67	13.05	5.74	9.10
	M4	1.02	23.90	13.96	25.00	696.25	123.33	11.65	5.48	8.87
	M5	1.02	24.68	12.88	27.33	741.25	110.00	12.47	5.39	8.59

Table (6) and Table (7), as well as Figure (3) and Figure (4), found that the NPI values for PO_4 concentration are less than one, suggest that the PO_4 concentration are within the allowable limit as per Iraqi and WHO standards. The NPI values for NO_3 concentration are not greater than one, indicate that the water samples are suitable for drinking, according to WHO standard, as well as, the water samples are suitable for irrigation as per Iraqi standard for both seasons in the study area, but the NPI values of NO_3 concentration vary from 1.16 to 1.38 during the cool season, means that the water samples are not suitable for drinking as per Iraqi standard.

Table (7): NPI values of Physico-chemical parameters in the hot season

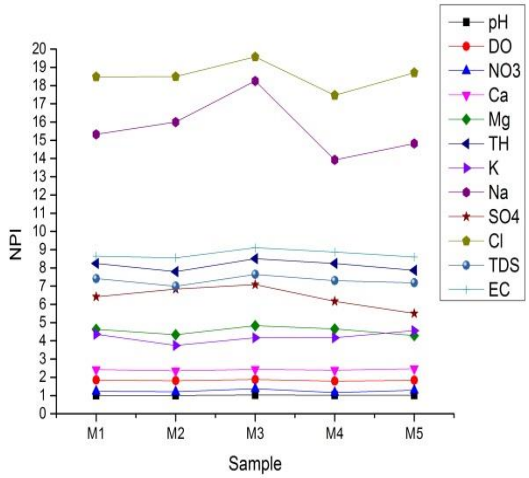
	NPI values											
Iraqi standard for Drinking	Samples	PH	DO	NO_3	Ca	Mg	TH	K	Na	SO_4	Cl	TDS	EC
	M1	0.94	1.49	0.99	0.96	1.23	2.49	1.71	5.48	1.44	6.37	2.59	2.91
	M2	0.94	1.38	1.02	1.03	1.19	2.52	1.88	5.48	1.44	6.46	2.68	2.96
	M3	0.95	1.44	1.05	0.98	1.27	2.56	2.25	5.70	1.50	6.59	2.70	3.01
	M4	0.96	1.49	1.03	1.02	1.33	2.69	1.92	5.58	1.50	6.97	2.89	3.18
	M5	0.95	1.41	1.05	0.99	1.32	2.64	1.92	5.50	1.47	6.55	2.75	3.07
WHO standard for Drinking water	NPI values												
	Samples	PH	DO	NO_3	Ca	Mg	TH	K	Na	SO_4	Cl	TDS	EC
	M1	0.94	1.49	0.22	2.55	3.68	2.49	1.71	5.48	2.30	5.09	7.76	5.82
	M2	0.94	1.38	0.23	2.74	3.58	2.52	1.88	5.48	2.30	5.17	8.04	5.91
	M3	0.95	1.44	0.23	2.60	3.80	2.56	2.25	5.70	2.40	5.27	8.09	6.02
	M4	0.96	1.49	0.23	2.71	4.00	2.69	1.92	5.58	2.40	5.58	8.68	6.36
	M5	0.95	1.41	0.23	2.63	3.96	2.64	1.92	5.50	2.35	5.24	8.26	6.15
Iraqi standard for Irrigation water	NPI values												
	Samples	PH	DO	NO_3	Ca	Mg	TH	K	Na	SO_4	Cl	TDS	EC
	M1	0.93	1.49	0.02	0.20	0.43	2.30	4.15	0.21	2.88	5.09	1.55	23.26
	M2	0.93	1.38	0.02	0.20	0.46	2.24	4.20	0.23	2.88	5.17	1.61	23.65
	M3	0.94	1.44	0.02	0.21	0.43	2.37	4.27	0.27	3.00	5.27	1.62	24.07
	M4	0.95	1.49	0.02	0.21	0.45	2.50	4.48	0.23	3.00	5.58	1.74	25.44
	M5	0.94	1.41	0.02	0.21	0.44	2.47	4.40	0.23	2.94	5.24	1.65	24.59
WHO standard for Irrigation water	NPI values												
	Samples	PH	Ca	Mg	K	Na	SO_4	Cl	TDS	EC			
	M1	0.94	9.56	3.68	10.25	273.75	28.75	4.24	1.94	2.91			
	M2	0.94	10.28	3.58	11.25	273.75	28.75	4.31	2.01	2.96			
	M3	0.95	9.76	3.80	13.50	285.00	30.00	4.39	2.02	3.01			
	M4	0.96	10.18	4.00	11.50	278.75	30.00	4.65	2.17	3.18			
	M5	0.95	9.88	3.96	11.50	275.00	29.38	4.36	2.07	3.07			

In the hot season of the study area, the NPI values of Ca concentration, as it is tabulated in Table (7), and as it was represented in Figure (4), varies from 0.2 to about one, for all the monitoring stations, propose that the water is suitable for drinking and irrigation as per Iraqi standard, but at the same time, The NPI values that calculated according to WHO standard, are more than one, show the not suitability of using the water for irrigation. Whereas, the NPI values of Ca concentration in the cool season, are greater than one, shows that the water in the study area are not allowable for drinking as per WHO and Iraqi standards, but its values varies between 0.23 to 0.28 in the cool

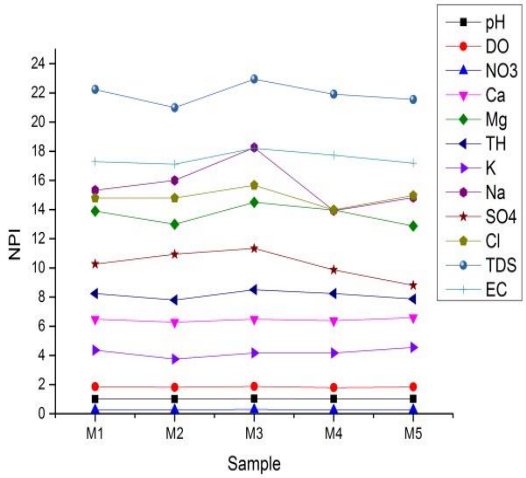
season, suggests that the water can be used for irrigation according to NPI values for Ca concentration as per Iraqi standard .

The NPI values of Mg concentration, as shown in Tables (6 and 7) and Figures (3 and 4), varies from 1.05 to 14.5 in the cool season, and varies between 0.43 to 4 in the hot season, indicate that the water samples are not suitable for drinking and irrigation as per WHO standard.

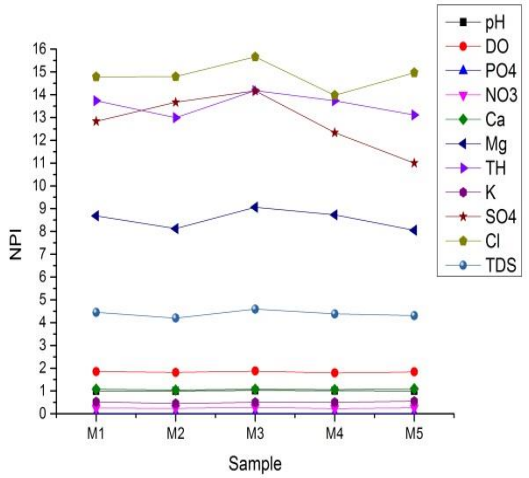
During the cool and hot seasons in the study area, it was noticed from the prepared Tables (6 and 7), that the NPI values of TH and K concentrations are more than one indicates not suitability of water samples for drinking and irrigation,



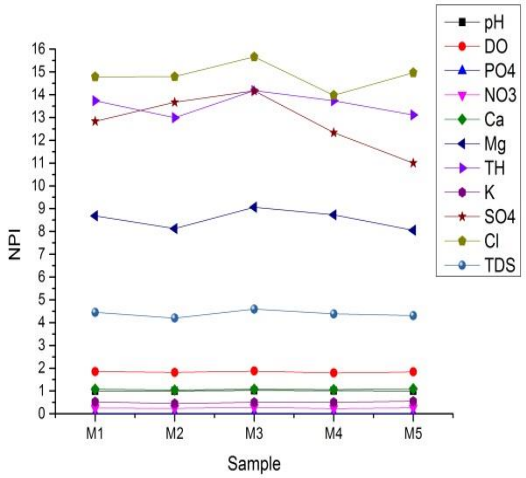
a- NPI values as per Iraqi standards for drinking water



b- NPI values as per WHO standards for drinking water



c- NPI values as per Iraqi standards for irrigation water



d- NPI values as per WHO standards for irrigation water

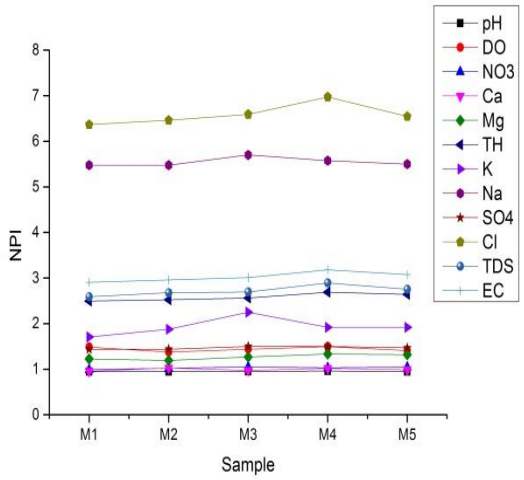
Figure (3): NPI values of the Physico-chemical properties of water samples in the cool season.

All the water samples from the monitoring stations have NPI values for SO_4,Cl, and Na concentrations, exceeding one, indicating the high level of pollution for these

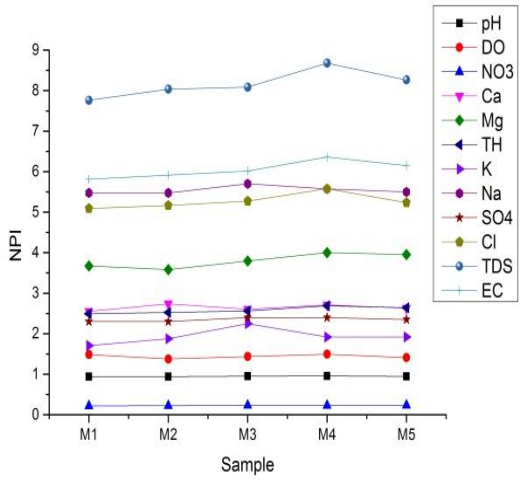
parameters. However, the NPI values for Na concentration varies from 0.21 to 0.27 in hot season, and range between 0.45 and 0.547 in the cool season.

NPI values for EC concentration in the study area, show very large values in cool and hot seasons (see Tables (6 and 7), Figures (3 and 4)) indicating the presence of higher amount of EC in the water samples.

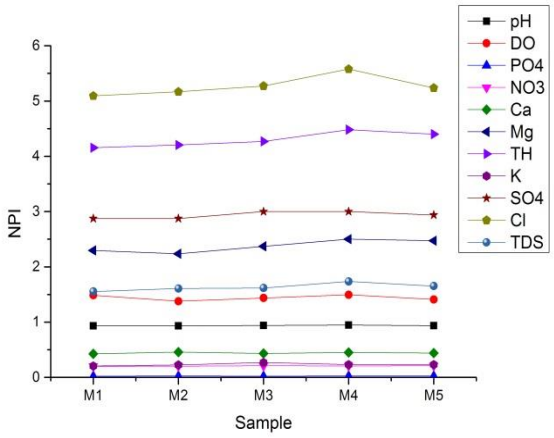
Finally, the NPI values of TDS concentrations in the study area found to be greater than one in cool and hot seasons, showing that the water samples are not allowable for drinking and irrigation as per Iraqi and WHO standards.



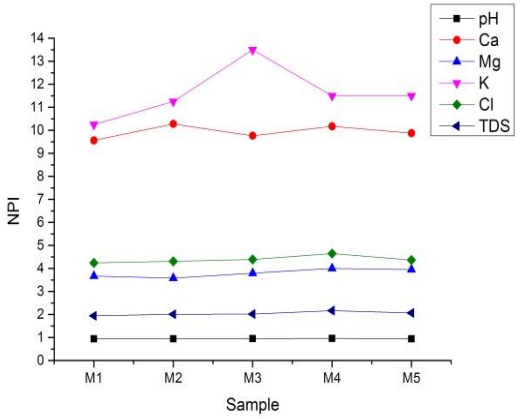
a- NPI values as per Iraqi standards for drinking water



b- NPI values as per WHO standards for drinking water



c- NPI values as per Iraqi standards for irrigation water



d- NPI values as per WHO standards for irrigation water

Figure (4): NPI values of the Physico-chemical properties of water samples in the hot season.

4. Conclusions:

The study area of this research is constantly under concerns due to the population is certainly increasing and there is more demand for water resources. The Nemerow pollution index (NPI) method to assess the water quality for drinking and irrigation, based on five monitoring stations in some Basrah marshes, was successfully applied. The results showed that the applied method is correct and reasonable. The concentration of

NO_3 is within the permissible limit for drinking purpose except in the cool season. The NPI values for pH, are within the allowable limits for drinking and irrigation purposes. In the assessment of water quality, most of pollutants' concentration exceeded the Iraqi and WHO standards and generate problems to the environment, thus the appropriate treatment is required for consumption of water samples for drinking and irrigation purposes, or else, people in the study area having health problems when using this water. So, there clearly was a need of regular monitoring of water quality and adequate plan for environmental management must be implemented to control water pollution.

References:

Buringh, Pieter, 1960, "Soils and soil conditions in Iraq", Ministry of agriculture.

Caeiro, S., Costa, M. H., Ramos, T. B., Fernandes, F., Silveira, N., Coimbra, A., and Painho, M., 2005, "Assessing heavy metal contamination in Sado Estuary sediment: an index analysis approach", Ecological indicators, 5.2, 151-169.

Federation, Water Environmental, and APH Association, 2005, "Standard methods for the examination of water and wastewater", American Public Health Association (APHA), Washington, DC, USA.

Hamzaoui-Azaza, F., Ketata, M., Bouhlila, R., Gueddari, M., and Riberio, L., 2011, "Hydrogeochemical characteristics and assessment of drinking water quality in Zeuss–Koutine aquifer, southeastern Tunisia", Environmental Monitoring and Assessment 174.1-4 , 283-298.

Jabbar, Mawahib F. Abdul, Ahmed F. Al-Ma'amar, and Ahmed T. Shehab, 2010, " Change detections in marsh areas, south Iraq, using remote sensing and GIS applications", Iraqi Bulletin of Geology and Mining, 6 (2), 17–39.

Kumar, M., Ramanathan, A. L., Rao, M. S., and Kumar, B., 2006, "Identification and evaluation of hydrogeochemical processes in the groundwater environment of Delhi, India" , Environmental Geology 50.7 , 1025-1039.

Kumar, S. K., Chandrasekar, N., Seralathan, P., Godson, P. S., and Magesh, N. S. , 2012, "Hydrogeochemical study of shallow carbonate aquifers, Rameswaram Island, India", Environmental monitoring and assessment 184.7 , 4127-4138.

Nemerow, Nelson Leonard, 1971, "Benefits of water quality enhancement", Environmental Protection Agency, Water Quality Office, for sale by the Supt. of Docs., US Govt. Print. Off.

Parizi, Hassan Sahraei, and Nozar Samani, 2013, "Geochemical evolution and quality assessment of water resources in the Sarcheshmeh copper mine area (Iran) using multivariate statistical techniques", Environmental earth sciences 69.5 , 1699-1718.

Rathod, Shantilal D., Mohammad Mohsin, and Mazahar Farooqui, 2011, "Water Quality Index in and Around Waluj–Shendra Industrial Area Aurangabad.(MS)," Asian J. Biochem. Pharmaceut, Res 1.2.

Richardson, Curtis J., and Najah A. Hussain, 2006, "Restoring the Garden of Eden: an ecological assessment of the marshes of Iraq", BioScience, 56.6 , 477-489.

Standard specification No,(417), 2009, "The Ministry of planning and development cooperation . Central organization for standardizations and quality control - Iraq", Second update (In Arabic).

UNEP, 2003, "Environment in Iraq", UNEP Progress Report, Geneva.

WHO, 2011, "Guidelines for drinking-water quality", WHO chronicle 38, Fourth Edition, 104-108.