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Water Quality Index (WQI) as indicator of the East Hammar marsh after sharpe salinity increase during summer 2018

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Abstract

The water quality of East Hammar marsh was evaluated using Principal Component Analysis (PCA) and Water Quality Index (WQI) of the Canadian Council of Environment Ministers (CCME), water samples were Collected monthly from three different stations of the marsh for the period from January to December 2018. The samples were analyzed for 15 physiochemical parameters of water quality: temperature, concentration of Hydrogen ion (pH), salinity, dissolved oxygen, BOD, COD, total hardness, calcium, magnesium, sulfate, phosphate, nitrate, sodium, bicarbonate. The result of the evaluation was that the quality of water in the East Hammar marsh, was poor in terms of protection of aquatic life, irrigation and drinking. The general index value was 31, 29 and 25 for the three stations respectively.

key words: East Hammar marsh, (WQI), Aquatic Environment, Iraq.

Introduction

Water quality depends on the physical, chemical, and biological parameter variables, including temperature, pH, dissolved oxygen, salinity and other factors (CCME, 2002). These variables are important in assessing water quality (Nagels, *et al.* 2002) Conservation of fresh water resources is important in countries around the world and requires monitoring programs to protect water sources from pollution (Pesce and Wunderlin, 2000). In general aquatic environments can be described as having a complex structure that requires careful use to ensure the sustainability of water system. As well as the management of water bodies environments ecosystem characteristics and the way which enable interaction between the change of life, chemical and physical processes (Al-Najare, *et al.*, 2012).

Water resources have received increasing attention by specialists in light of the increasing need to secure the requirements of agricultural, industrial and environmental recovery and ensure the vocabulary of food security, accompanied by attention to the deterioration of water quality as a result of continuous pollution in water resources sources, and that the Iraqi rivers suffer from an increase in pollution levels, especially in recent years due to the direct discharge of domestic and industrial wastes in various forms to the untreated aquatic environment, as well as seriously reduced water levels in rivers, which are the main nutrient source of the marshes (Hantoush, *et al.*, 2013). Therefore, the process of maintaining water quality from deterioration requires the application of efficient monitoring methods in the delivery of the necessary information on water quality in a simplified and accurate to specialists and decision-makers, as it is based on that information in the appropriate decisions and policies to protect against change (Karakaya and Evrendilek, 2010), Although there are many scientific methods used to assess water quality, it is not easy to say that water is good or not good. Water may be suitable for a particular purpose, but they are not appropriate to be used for another purpose, as required water quality depend on the purpose of use (Al-Najare, 2015).

In case of use WQI is very important to determine the period needing to evaluated the state of water, usually require for one year monitoring because the data is usually collected monthly or quarterly (CCME, 2001).

The present study aims to study the physical and chemical characteristics of the marsh due to the significant decline in fresh water levels, in addition to the entry of large quantities of sea water due to the progress of the salt tongue due to the lack of water releases and the possibility of use in drinking and irrigation.

Materials and methods

Three stations were selected to evaluate the water quality of the East Hammar marsh:

The first station (Harir) is located in the coordinates 47˚ 41ˊ 37˝ E and 30° 35′ 17.6″ N and away from the bridge of Karma about 4.5 km and this area was not subject to drying as in other areas of the marsh, depth at the middle of the course between 5.5-8 m and is characterized by water transparent to west of the southern part of the east of Hammar marsh were sampled from the main riverbed.

The second station (Sallal) is located north of the first station, which is about 4 km, located within the coordinates 47° 39′ 19.7″ E and 30° 38′ 17″ N. Depth is between 4-6 meters This area was subjected to a complete drying and re-flow of water after removing the dam of sallal by the people in 2003.

The third station (Al-Barga) is 15 km away from the first station, which is located in the coordinates of 47° 36′ 44.8″ N and 30° 41′ 11.5″ E. The area is shallow and the water depth in some areas is less than 1 meter.

The current study period was divided into two periods. The first period represents the results of six months starting from January 2018 to May 2018, which is the wet and dry season such as the results of six months from July 2018 to December 2018, the use of YSI-665MPS included water temperature (˚C), salinity concentration ($gm.l^{-1}$), dissolved oxygen concentration ($mg.l^{-1}$) and pH, the amount of oxygen bio-requirement (BOD_5) was calculated according to the method described by the association. American Public Health (APHA, 2005), the quantitative chemical requirement of oxygen was measured based on (APHA, 1999) using COD Kits according to the Closed Reflux, Titrimetric Method by using Riley and Chester (1971) method that laboratory modulated to calculate active nitrates and nitrites. The method adopted by Riley, and Chester (1971) for the calculation of active phosphorus, followed the method described by (APHA, 2005) for the determination of sulfates. Measuring the concentration of sodium, potassium, chloride and calcium, as well as the total hardness according to the method described in (APHA, 2005), extracted the magnesium values by the calculation method (Eaton 2005). The method adapted by Lind (1979) for the determination of total alkalinity

Table 1: Water Quality Index Scale (Hassen *et al.*, 2013)

Classification of the Model	**The value of the directory**	**the description**
Excellent	100- 95	Water is well protected and free from pollution as it approaches the ideal water
Good	94- 80	Water is less protected and rarely departs from ideal specifications
Fair	79- 65	Water is often protected but contaminated and .is sometimes departed from the ideal state
Marginal	64- 45	Water is frequently polluted and is often far from ideal
Poor	44- 0	Water is permanently exposed to pollution .and is far from ideal at all times

Results

The values of the water quality index (WQI) for the study stations varied as shown in Table (2). They were divided into two sections the first one was before the salt tide. The second section was after the salt tide and it was calculated on an annual basis. The three stations were classified as Poor for the duration of the study.

The results of the analysis of (PCA) in the relationship between the environmental factors as in Figure (1) overlap the environmental factors in the station 1 and the average effect is at the top of the overlap of the factors in the first effect and then comes the effect of the second factors, according to the order and depends on the type and strength of the factor, that the differences in the values of the evidence showed some stations and different seasons may not be the result of the number of variables that have departed from their standard specifications, which are calculated by the value of the range (F1) or the number of tests in which these Variables for their standard specifications, which are calculated through the frequent values (F2). It is mainly due to the deviation in which the values of the concentrations of the variables departed from their standard specifications, which are calculated by the interference of factors. Figure (2) indicates the water quality variables responsible for the changes in the values of the water quality index. According to the program of principal components analysis (PCA) in the same station, which was divided into two groups, the first had a positive correlation and the second group had a negative correlation and according to the figure as it shows the distribution of the factors strength due to the environmental work force associated with the rest of the factors other than (COD). A weak negative link appears The PCA analysis shows the effect of the interaction of environmental factors during the months if the heat, sodium and total alkalinity were associated with the summer months, while (DO, BOD) were positively correlated with the winter months. The effect of one factor strength on another factor with different months and seasons of overlap in the environmental factors in Harir station, where the factors were distributed over the months with the relative differences between the factors, the distribution is taken as the working force during the Month.

Table (1) correlation of environmental factors in the stations during the study

Variables	temp.	sal	Ph	DO	BOD	Cl	Ca	Mg	HCO_3	PO_4	Na	COD	SO_4	NO_3	TH
temp.	1	0.500	0.072	-0.285	-0.826	0.419	0.292	0.581	0.332	-0.218	0.784	0.197	-0.056	-0.099	0.529
sal	0.500	1	-0.177	-0.531	-0.749	0.919	0.841	0.796	0.596	-0.360	0.771	-0.167	0.243	0.133	0.930
Ph	0.072	-0.177	1	0.106	0.075	-0.317	-0.199	0.007	0.038	-0.532	0.103	0.059	-0.263	-0.270	-0.128
DO	-0.285	-0.531	0.106	1	0.486	-0.284	-0.455	-0.637	-0.375	0.273	-0.409	-0.209	-0.103	0.497	-0.596
BOD	-0.826	-0.749	0.075	0.486	1	-0.697	-0.699	-0.726	-0.446	0.336	-0.808	-0.140	-0.358	-0.110	-0.845
Cl	0.419	0.919	-0.317	-0.284	-0.697	1	0.876	0.564	0.642	-0.127	0.582	-0.272	0.427	0.398	0.839
Ca	0.292	0.841	-0.199	-0.455	-0.699	0.876	1	0.549	0.693	-0.251	0.488	-0.112	0.696	0.247	0.898
Mg	0.581	0.796	0.007	-0.637	-0.726	0.564	0.549	1	0.335	-0.377	0.884	0.093	-0.016	-0.127	0.850
HCO_3	0.332	0.596	0.038	-0.375	-0.446	0.642	0.693	0.335	1	-0.104	0.244	0.100	0.416	0.145	0.573
PO_4	-0.218	-0.360	-0.532	0.273	0.336	-0.127	-0.251	-0.377	-0.104	1	-0.470	-0.079	0.082	0.025	-0.338
Na	0.784	0.771	0.103	-0.409	-0.808	0.582	0.488	0.884	0.244	-0.470	1	-0.015	-0.085	-0.085	0.788
COD	0.197	-0.167	0.059	-0.209	-0.140	-0.272	-0.112	0.093	0.100	-0.079	-0.015	1	0.210	-0.193	-0.009
SO_4	-0.056	0.243	-0.263	-0.103	-0.358	0.427	0.696	-0.016	0.416	0.082	-0.085	0.210	1	0.323	0.435
NO_3	-0.099	0.133	-0.270	0.497	-0.110	0.398	0.247	-0.127	0.145	0.025	-0.085	-0.193	0.323	1	0.074
TH	0.529	0.930	-0.128	-0.596	-0.845	0.839	0.898	0.850	0.573	-0.338	0.788	-0.009	0.435	0.074	1

Table 2 The values of the Water Quality Index (WQI) and classification categories of the stations according for Table (1)

Station	Time	WQI	
		Value	Classification
Harir	Before the salt tide	40	Poor
	After the salt tide	27	Poor
	Annual Evaluation	29	Poor
	annual rate	31	Poor
Sallal	Before the salt tide	38	Poor
	After the salt tide	22	Poor
	Annual Evaluation	27	Poor
	annual rate	29	Poor
Al-Barga	Before the salt tide	32	Poor
	After the salt tide	20	Poor
	Annual Evaluation	24	Poor
	annual rate	25	Poor

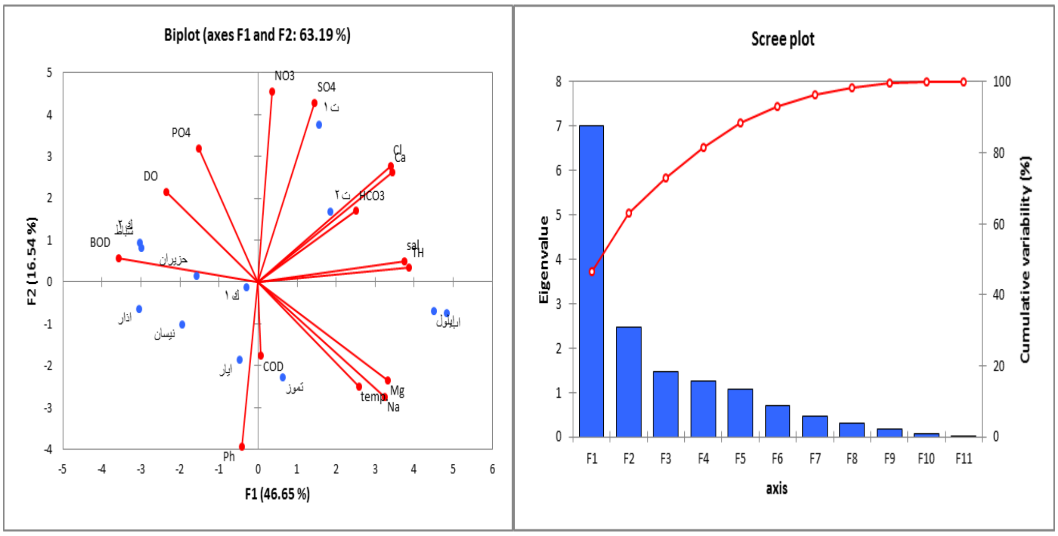

Figure 1 Interference of environmental factors in Harir station during the study

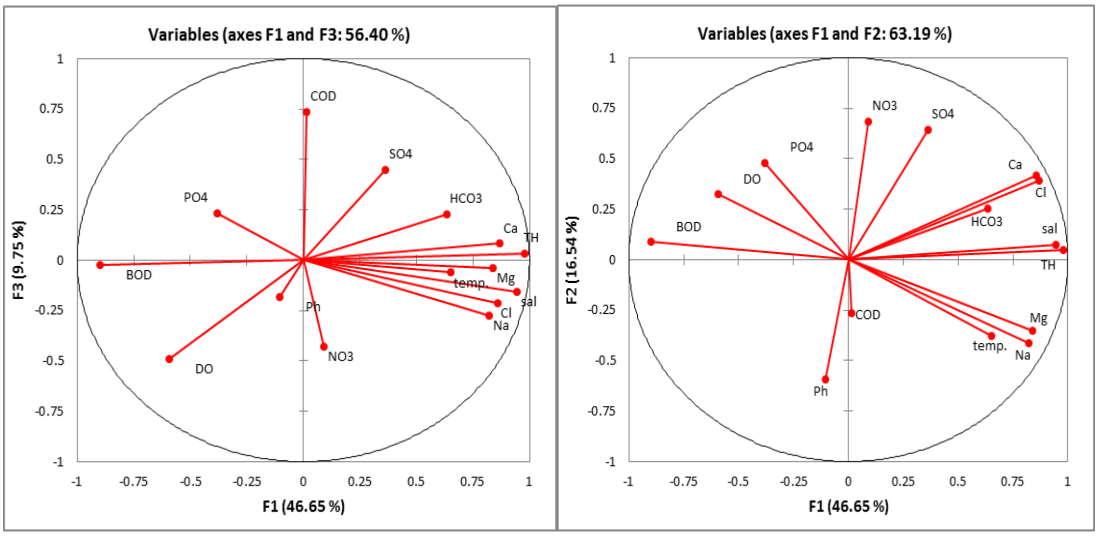

Figure 2: Water Quality Variables by Principal Component Analysis Program (PCA) at Harir Station

The results of the PCA analysis showed the relationship between the environmental factors as in Figure (3) the interference of the environmental factors in Sallal station and that the average effect is at the top of the overlap of the factors in the first effect and then the second effect of the factors according to the order and depends on the type and strength of the factor and its association with the rest. Factors, and the water quality variables responsible for the changes in the values of the water quality index according to the principal components analysis program (PCA) in the same station, which were equally distributed between the first effect (F1) and the interference with the second effect (F2) where they were positively correlated. Except the (COD), which showed a weak negative correlation According to the figure with the nutrients and dissolved oxygen, it shows the distribution of force factors due to the strength of the environmental factor associated with the other factors, while the variables in water quality responsible for the change in the values of WQI (F1) and its association with (F3) and their association with other factors in the second station. The interaction of the factors had a significant positive correlation, while the temperature was highly correlated with salinity, calcium ions, sodium, bicarbonate and total hardness, while it was negatively correlated with the biological requirement of oxygen, total phosphorus and nitrates in addition to pH. This shows a negative correlation. DO, BOD are positively correlated, temperature, alkalinity and COD are negatively correlated, while nutrients are correlated positively. Figure (1) shows PCA analysis, the environmental factors during the months where the interaction between the effect of (F1) with (F2) where the temperature, sodium, pH and oxygen chemical requirement with the summer months were positively correlated, while (DO, BOD) was positively correlated with the winter months. With the (COD) negative, the latter was positively correlated with the month of July, Figure (4) shows the effect of the interaction of environmental factors during the months was associated with the effect of (F1) with (F3) has been the power of the factors were distributed over different months of the year as the impact of the strength of the factor on another factor with different months and seasons, where salinity, sodium and chlorine were associated with the month of July and September 2018. Bicarbonate, total hardness, calcium and sulphate were significantly correlated with August and November 2018, while dissolved oxygen, BOD and some nutrients were associated with the winter and spring months were high positively significantly correlated.

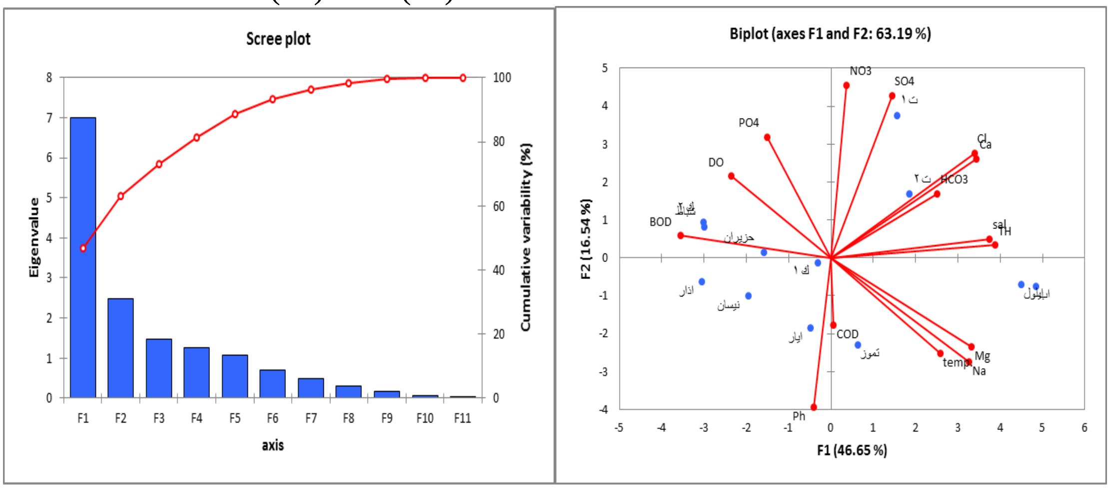

Figure 3: PCA analysis shows the annual impact of interference to environmental factors in Sallal station

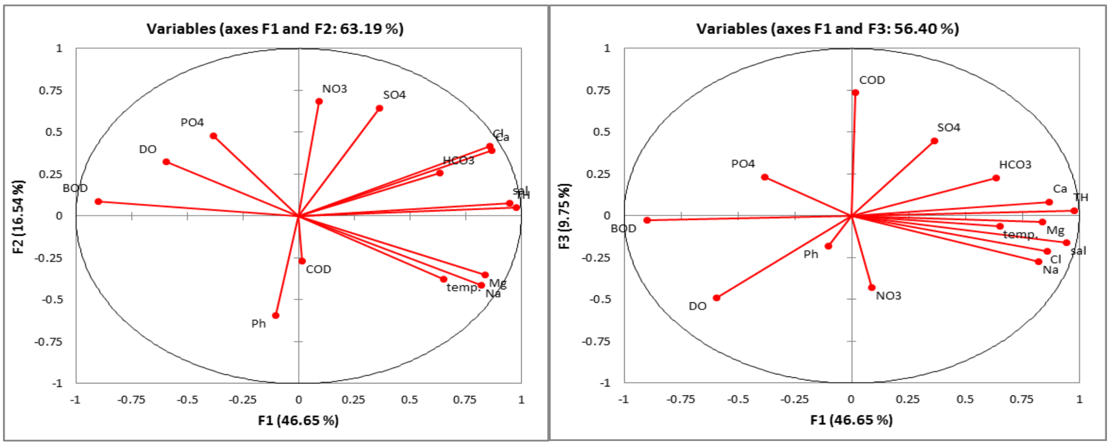

Figure 4: Water Quality Variables by Principal Component Analysis (PCA) Program at Sallal Station

The results of analysis (PCA) in the relationship between environmental factors as in Figure (5) overlap of environmental factors in the Al-Barga station and that the average effect is at the top of the overlap of factors in the first effect and then comes the second effect of the factors and in order and depends on the type and strength of the factor and its association with the rest factors, water quality variables responsible for changes in the water quality index values according to the PCA program at the same station which are unevenly distributed between the first effect (F1) and the interference with the second effect (F2) as they had a positive significant correlation With most of the influential elements except (DO, BOD, pH, PO_4) which showed a strong negative moral correlation and according to the figure as it shows the distribution of the power of the factors due to the strength of the environmental factor associated with the other factors, while the variables in water quality responsible for the change in the values of WQI (F1) and its association with (F3) and their association with factors In the third station, the interaction of the factors was mostly positively correlated while the temperature was highly correlated with the chemical requirement as well as the total correlation positively correlated with manganese ions, bicarbonate, calcium ions, chlorine, sodium and salinity. Negative nuclei with the biological requirement of oxygen, total phosphorus and nitrates in addition to the pH which shows a negative correlation. Both (DO, BOD) were positively correlated while alkalinity temperature, alkalinity and COD were negatively correlated while nutrients were correlated with each other. Figure (6) shows the effect of the interaction of environmental factors during the months, where the interaction between the effect of (F1) with (F2) as the temperature, total phosphorus and oxygen chemical requirement with the summer months were positively correlated, Spring was positively correlated with DO and BOD and COD PCA analysis shows the effect of interference of environmental factors during the months as the effect of (F1) with (F3) has been distributed to the strength of the factors over the months of the year. The effect of the strength of one factor on another factor with different months and seasons, as positively correlated with sodium ions, chloride, manganese ions and total hardness with Oct. and Nov. months.

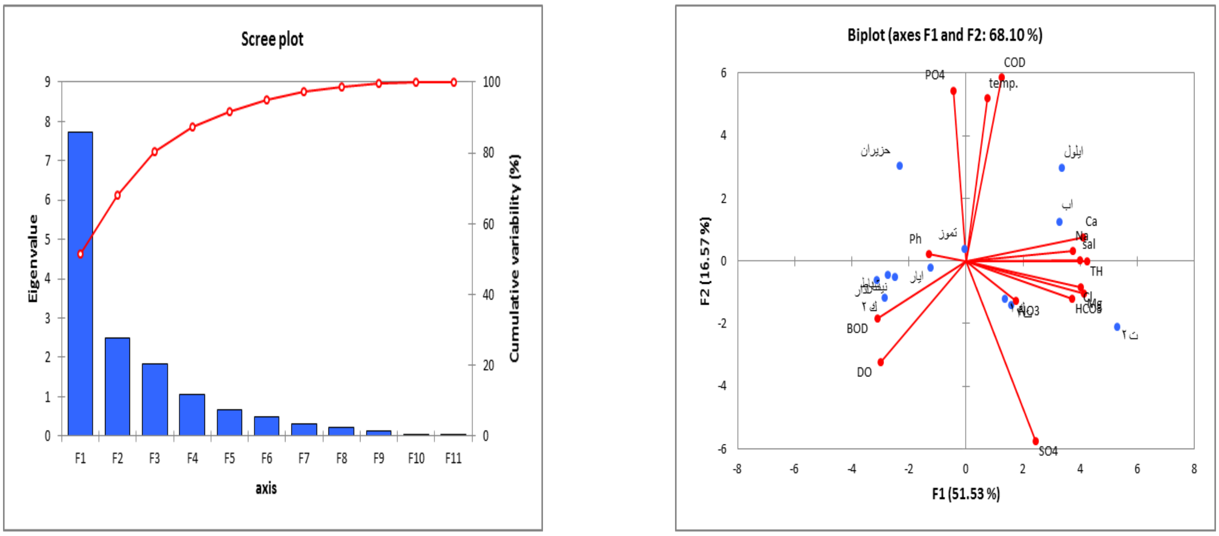

Figure 5: Interference of environmental factors in Al-Barga Station

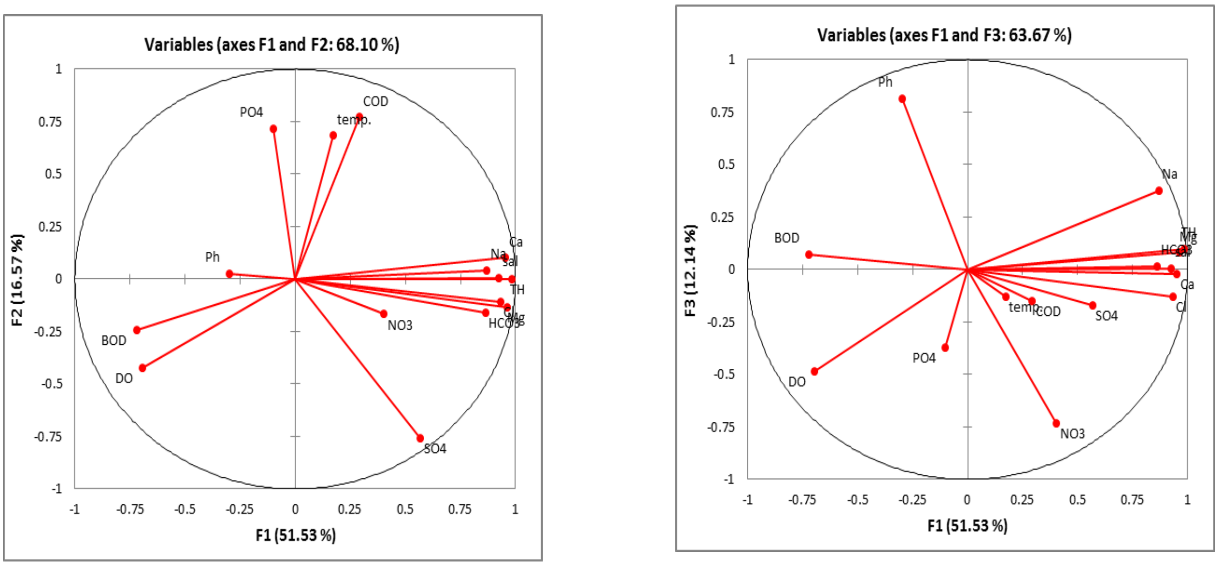

Figure 6: Water Quality Variables by Principal Component Analysis Program (PCA) at Al-Barga Station

Discussion

The Water Quality Index (WQI) was used to give an idea about the quality of the water of the East Hammar marsh summarize several data on water quality and a variety of chemical, physical and biological variables, as well as give a visualization of the water surface (CCME, 2001) and what is the effect of the salt wedge tied water and Shatt al-Arab Water quality and fish diversity in the area of East Hammar marsh, a model that allows researchers to choose variables and compare them with the standard limits, as the quality of water in the study sites were classified under the fifth category (Poor) and this is related to the deterioration of water quality in the course of the Shatt al-Arab River, coming from the Arabian Gulf, which resulted in an increase in the concentration of salts and increased bio-oxygen demand and total clear brackish values during that period, the impact of the sea front, as well as the apparent decrease in dissolved oxygen values due to increased concentration of organic waste and high temperatures.

As mentioned by Al- Mahmood, *et. al.*, (2015) the discharge the Shatt al-Arab River has affected the quality of the river water as a result of the construction of dams in the upper basins of the Tigris and Euphrates Rivers and agricultural activities in addition to the penetration of salt tide and thus its impact on the water of the marsh, and this is what many researchers pointed out The water quality in the east Hammar marsh after the inundation increased to 60 as a result of the low inundation ratio which was 34% (Al-Saboonchi, *et. al.*, 2011) and classified by Mohammed (2014) on a marginal basis, Shatt al-Arab water only as the Euphrates was cut off, causing salinity of the east Hammar to rise (Al-Tememi, *et. al.*, 2015). The summer season was the most deteriorating in the values of the index, as the decline in the values of the index indicates that the waters of the Marshes are unsuitable for drinking, but need advanced treatment to become valid. Calculate the evidence for the Iraqi and international standard parameters for drinking purposes, especially salinity, total soluble solids, total alkalinity, calcium, magnesium, sodium, chloride, total hardness, sulphates, biomass and chemical requirements. WQI between some stations or different seasons may not be due to the number of variables that have departed from their standard specifications, which are calculated by the value of the range (F1), or by the number of tests in which these variables have departed from their standard specifications, which are calculated from the value differences. Frequency (F2) but mainly resulted by the extent of deviation in which the values of the concentration of variables away from their standard specifications, which is calculated by the value of abundance (F3) This was observed through the equality of some stations and seasons in the number of variables and the number of tests in which they deviated from the standard specifications, but were different in the amount of deviation of the values of the concentrations of these variables resulted in this slight variation between them throughout the study period. When comparing the values of the qualitative evidence of the stations we find that the spatial differences were minor, as the third station is an extension of the second station, an extension of the first station that feeds from the Shatt al-Arab River and therefore affected by the quality of its water, the marsh water in subsequent studies, as well as to find the relationship between those variable and water quality index, as the length of the arrow and direction in Figure (2) represents the relative importance between those variables and the directory. The results of PCA analysis showed that all water quality variables were inversely correlated with the general evidence of water quality index, i.e. the cause of the deterioration of water quality and all according to the strength of its effect except chemical requirement and PH which was inversely correlated due to its acceptable values throughout the study period. The values of calcium, chlorine, magnesium, sodium, salinity and total hardness were the most influential water quality variables on the variability in the water quality index. In the general guide to water quality, where the most variable variables are responsible for the variability in water quality in general, followed by the bio-requirement of oxygen and dissolved oxygen and nitrate sulfate and phosphate water temperature bicarbonate respectively The results of the present study differed from many studies in the region and the Shatt al-Arab, like Radi (2014) study which classified the marsh water as acceptable for irrigation purposes, as well as a study of Moyel (2011) on the Shatt al-Arab, which classified water as falling within a good for irrigation purposes and a study of Hamid (2017) on the Karmat-Ali River as most studies recorded an acceptable classification for the same purpose, has been classified east Hammar marsh during the period (2005-2006) due to the deterioration of water quality in the category of poor according to the data of AL-Saboonchi *et. al.,* (2011), while the marshes, especially the marshe Al-jbayish for the years (2005-2008) and Hawiza in the marginal category has been classified Al-Hammar marsh at a higher rate of water quality according to the water quality index within the same period studied (Hussain *et. al.,* 2010; AL-Ansari *et. al.,* 2012). Current head from most of the results of previous studies, due to the reason of the Arabian Gulf water control water marshes ass area being the main nourishing the of the region and change the whole entire water mass.

Conclusions

There are no significant differences between the study stations and these indicates that the water mass is the same and affect the whole region tidal operations. The quality of the water of the East Hammar marsh is not suitable for drinking or for agricultural use, with an unprecedented rise in salinity values.

Recommendations

Improve the quality of water of east Hammar marsh through the restoration of the old earth dam linking the waters of the Euphrates River to the north and west of the Marsh and the installation of excess water drainage pipes.

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دليل نوعية المياه WQI كمؤشر لهور شرق الحمار بعد ارتفاع الملوحة الحادة خلال صيف 2018

المستخلص

تم تقييم نوعية مياه هور شرق الحمار الذي يعد أحد اهم اهوار جنوب العراق الرئيسية من ناحية صالحيتها للحياة المائية وللري باستخدام تقنية تحليل المكونات الأساسي (PCA) ودليل نوعية المياه لمجلس وزراء البيئة الكندي CCME. WQI- جمعت عينات المياه شهريا من ثلاث محطات متفرقة من المنطقة للمدة من كانون الثاني لغاية كانون الأول عام 2018 وتم تحليل 15 من المعايير الفيزوكيميائية لجودة المياه وهي: درجة الحرارة ، تركيز أيون الهيدروجين (pH)، الملوحة، الأوكسجين المذاب، ال BOD، ال COD، العسر الكلية، الكالسيوم، المغنسيوم، الكبريتات، الفوسفات، النترات، الصوديوم، البيكربونات. نتيجة التقييم كانت هي ان نوعية مياه هور شرق الحمار ضعيفة بالنسبة لحماية الحياة المائية وللري وللشرب وكانت قيمة الدليل العامة 31 و29 و25 للمحطات الثلاث على التوالي اعتمادا على دليل النوعية وبذلك صنفت المحطات الثلاثة ضمن فئة فقيرة Poor طيلة مدة الدراسة.

الكلمات المفتاحية: شرق الحمار، النموذج الكندي، البيئة المائية، العراق.