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RESEARCH ARTICLE

Study the Temporal and Spatial Changes in Water Quality of Sabzposhan Wetlands by Water Quality Index (WQI)

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Abstract

To evaluate the quality of Sabzposhan Wetlands in Haji Abad – Bandar-E-Abbas province by index WQI, 10 stations were selected and 3 reps at each station, from April 2013 to March 2014, sampling was done with the frequency of 45 days. Using 9 water quality parameters including nitrate, nitrite, alkalinity, hardness, turbidity, electrical conductivity, dissolved oxygen, pH, BOD5, water quality index (WQI) was evaluated; for this purpose, a weight (AW) from 1 to 4 was allocated to each of the parameters, based on their importance in aquatic life and its role in the use of water resources for human consumption. Analysis of variance of the data obtained from the WQI showed significant differences between different times ($p<0/01$). Obtained results located the water quality in the 2 very poor and inappropriate class and it was found that the wetlands were unfit for human consumption, especially not suitable for drinking. The most important factor in evaluation of water quality based on this index was BOD5. Finally, the results of this study show that this method can be used to assess water quality and aquatic ecosystems used for human consumption.

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INTRODUCTION

Human development and expansion of economic activities, will undoubtedly lead to an increased need for water for different purposes. Water resources in the country, especially in the last three decades, influenced by the excessive consumption of different applications and due to climatic changes during these years, has experienced a significant reduction in the amount. Water quality is certainly influenced by the quantity and quality of its various applications. The national planning and resource management, therefore, all are in relation to the priority of usage of water resources. Term "water quality" has developed to achieve a comprehensive understanding of how to use the water for human consumption (Vaux, 2001). The term is widely used in various fields and issues related to them and is known as a need for water resources management (Parparov et al., 2006). Water quality in aquatic ecosystems is determined by a number of physical, chemical and biological factors (Sargaonkar and Deshpande, 2003). The important issue of water quality monitoring, then, is a complex correlation between the numbers of measured variables (Boyacioglu, 2006). The variability of water resources caused by natural and human activities (Simeonov et al., 2002). There are many methods for analysis of water quality data that according to the purposes of studies, sampling, and sample area and size of the study are different. For example, some methods are employed like WQI index for classification, modeling and interpretation of water resources (Boyacioglu, 2007, Simeonov et al., 2002), one of the most effective methods of water quality evaluation is using the proper evaluation indices (Dwivedi, 2007).

This indicator is based on different measures of physical, chemical and biological parameters in a water sample. The use of indicators in monitoring programs to assess ecosystem health is very good and could be used as a criterion for successful evaluating and appropriate management strategies to improve the quality of water used (Rickwood and

Carr, 2009). Water quality index (WQI) can use a set of water quality data and information at various times and places and transform their information to a single value for a period of time and place (Shultz, 2001). Therefore, this study attempts to evaluate the temporal and spatial changes in water quality in In-Green Wetlands, by water quality index (WQI) from the point of view of aquatic fitness standards and international standards for human consumption.

Materials and Methods

The study area covers about 200 acres of Sabzposhan wetlands, located in Sabzpooshan village - Haji Abad town – Hormozgan province. The area is located in 52' 55◦ to 53' 55◦ easten latitude and 16' 28◦ to 18' 28◦ northen longitude. Samples were collected from May 2013 to March 2014, in 8 steps with an interval of 45 days in 4 seasons. In this study, 10 sampling stations were considered so that the distance between adjacent stations was 1 km from each side. Locations were shown accurately on the map using a topographic map and the networking method and the intersection of grid lines were selected as sampling stations. To access this part, GPS device was used (Tiner, 1999).

To take samples of water at each station, after washing sample container 3 times with wetland water, one liter of water from a depth of 30 cm was harvested and transported to the laboratory under standard conditions. The physicochemical parameters 9 parameters were calculated including nitrate, nitrite, alkalinity, hardness, turbidity, electrical conductivity, dissolved oxygen, pH, BOD5. The values used for each parameter are the mean of 3 replicates per station per step process.

Physicochemical parameters such as water temperature, dissolved oxygen and percent oxygen saturation were measured at the station using a portable device.

Temperature using a mercury thermometer with accuracy 0/1 ° C, dissolved oxygen using oxygen meters WTW-OXI 196 models made in Germany, EC, pH and turbidity using a digital pH meter Schottgerate the 666,221 units produced in Germany, and an EC digital meter model CIBA, CORNING makes America, and turbidity meter model DRT-15CE was measured, respectively. BOD5 using residual oxygen method after 5 days by oxygen meter (APHA, 1992), nitrate and nitrite ions by colorimetric assay and measuring by optical spectroscopy, respectively, by a spectrophotometer model AANALYST 700 PERKIAN ELMER and spectrophotometer model JENWAY 6400, made in England, were measured (APHA, 1992). Alkalinity using a colorimetric method and performing the titration (APHA, 1992) and the hardness by EDTA titration method (APHA, 1992) was measured.

Statistical analysis

Statistical analysis of the data in the spatial (various stations) and time, frequency (in various stages of sampling) was performed by (SPSS, 20). First, the normality of the data was evaluated using the Kolmogorov-Smirnov test, and homogeneity of variance was assessed using Levene test. To evaluate the differences between the stations and times of the sampling, the ANOVA was used followed by Duncan's test to compare means. Finally, to provide spatial and temporal changes in the data, as well as to obtain an overview of the changes Wetlands, Box and Whisker Plot diagrams were designed using the software Statgraphics.

WQI Index Detection

To estimate the numerical values of WQI index the parameters were used which have been studied of the point of human interest and relevance for human consumption. In this study, the standard recommended by the World Health Organization (WHO) and drinking water standards in Iran were used (WHO, 2004). The calculation of this index includes the following steps:

Step 1: A weight (AW) from 1 to 4 for each parameter, according to expert opinion was allocated in previous studies (Abrahão, 2007, Boyacioglu, 2007, Chougule, 2009, Dwivedi, 2007, Kannel, 2007, Karakaya, 2009, Pathak and Banerjee, 1992, Pesce, 2000), the mean values for the given weights for each parameter with the used resources are provided in Table 1. The weight ratio of 1 to 4 is the least and most significant correlation, respectively.

Step 2: The ratio (RW) was calculated using equation 1.

$$RW = AW/\sum AW \qquad (1)$$

Where, RW is weight ratio and AW is the weight assigned to each parameter (on the table). Calculations the ratio of the parameters is presented in Table 2.

Table 1: The weight assigned to each parameter in different sources and their average with the relevant references

Parameters	Nitrate (mg/l)	Nitrite (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Turbidity (NTU)	EC (µs)	DO (mg/l)	pH	$BOD5_5$ (mg/l)
Abrahão et al., 2007	2	2	-	1	4	4	4	1	3
Boyacioglu 2007	3	-	-	-	-	-	4	1	2
Chougule et al., 2009	-	-	3	2	-	4	4	4	4
Dwivedi and Pathak., 2007	-	-	1	1	2	2	4	4	3
Kannel et al., 2007	2	2	-	1	-	1	4	1	3
Karakaya and Evrendilek., 2009	2	2	-	1	2	2	4	1	3
Pathak and Banerjee., 1992	-	-	1	1	2	2	4	4	3
Pesce and Wunderlin., 2000	2	2	-	1	2	4	4	1	3
Average	2/2	2	1/6	1/1	2/4	2/7	4	2/1	3

Table 2: The weight ratio of the water quality parameters

Parameters	Drinking Water Standard (WHO, 2004)	Aquatic Standard (CCME, 2006, Lumb *et al.*, 2002)	Allocated Weight (AW)	Ratio Weight (RW)
Nitrate (mg/l)	50	13	2/2	0/099548
Nitrite (mg/l)	3	0/06	2	0/090498
Alkalinity (mg/l)	100	-	1/6	0/072398
Hardness (mg/l)	500	-	1/1	0/049774
Turbidity (NTU)	5	5	2/4	0/108597
Conductance (sµ)	250	-	2/7	0/122172
Solved Oxygen (mg/l)	5	5/5	4	0/180995
pH	6/5-8/5	6/5-9	2/1	0/095023
BOD_5 (mg/l)	5	-	3	0/135747
Total			22/1	1

Step 3: A scale for measure of quality (Q_i) with respect to Eq. 2 was assigned to all parameters except pH and DO were assigned 2 and 3 was used for pH and DO of the relationship.

$$Q_i = (C_i / S_i) \times 100 \qquad (2)$$

$$Q_i = (C_i - V_i / S_i - V_i) \times 100 \qquad (3)$$

Where Q_i is the quality level, C_i is the results of any laboratory parameter, S_i is the report of the international standards or/and standards of the Iran, and V_i is the optimal amount equal to 7 for pH and 14/6 for DO. (Alobaidy et al., 2010).

Step 4: Finally, to calculate the WQI, first, sub-index SI_i was calculated for each parameter (Equation 4) and the numeric value of WQI was calculated from total of SI_i (Equation 5). The water quality class, finally, was determined using Table 3.

$$SI_i = RW \times Q_i \qquad (4)$$

$$WQI = \sum SI_i \quad (5)$$

Table 3: Categorization based on the overall index score WQI (Ramakrishnaiah et al., 2009)

Quality class	The Obtained Index
Great	< 50
Good	50-100
Poor	100-200
Very Poor	200-300
Inappropriate	300

Results

Figure 1 shows the changing of the indices WQI in studying stations. By pollution, the value of this index increased. In general, no significant differences were observed between the different stations (p >0/05).

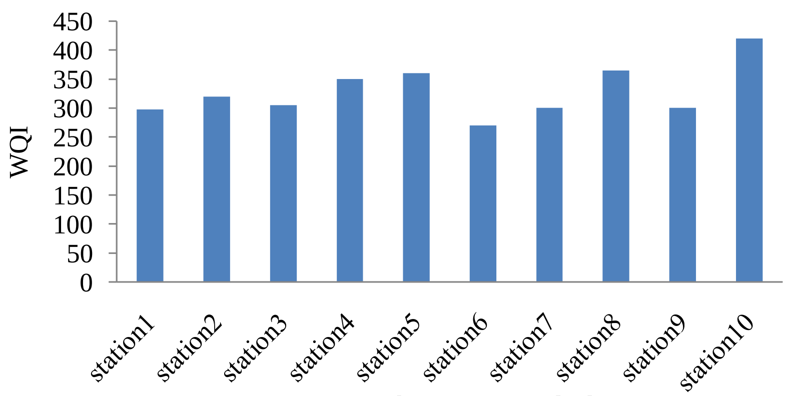

Figure 1:WQI Changing in studied Station

Figure 2 shows the index WQI at various stages of sampling. The highest level of this index in Stage 4 (late summer) and the lowest in step 7 and 8 (winter) is obtained. There were significant differences between the various stages of sampling (p<0/01).

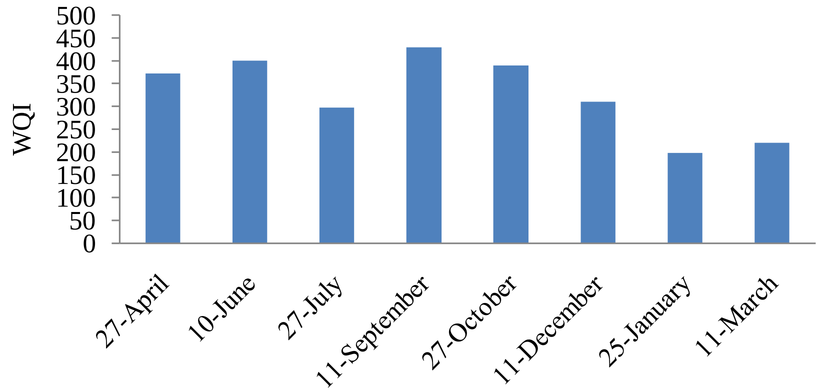

Figure 2:WQI at various stages of sampling

Table 4: Statistical Data Summary of sabzposhan Wetland Water Quality

Parameters	Min	Max	Mean ± SD
Nitrate (mg/l)	0/060	0/406	0/195 ± 0/077
Nitrite (mg/l)	0/007	0/095	0/038 ± 0/016
Alkalinity (mg/l)	108	200	140/718 ± 20/299
Hardness (mg/l)	174/157	480/432	314/625 ± 95/339
Turbidity (NTU)	10/712	70/787	26/506 ± 12/389
Conductance (sµ)	202	378	266/337 ± 37/422
Solved Oxygen (mg/l)	4/400	14/400	9/317 ± 2/087
pH	7/440	10/450	9/123 ± 0/752
$BOD5_5$ (mg/l)	9	280	72/587 ± 51/368

Table 4 shows the average, maximum, minimum, and standard deviation calculated for each of the 9 physicochemical parameters and the correlation between the WQI and water quality parameters is shown in Table 5. Generally, positive and negative correlations were observed between numbers of parameters with each other and with the index WQI. Regardless of their purely numeric relationship which does not seem logical, the rest of them were analyzed and discussed.

Table 5: Pearson correlation coefficients between water quality parameters and WQI indicators

Parameters	Nitrate (mg/l)	Nitrite (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Turbidity (NTU)	EC (µs)	DO (mg/l)	pH	$BOD5_5$ (mg/l)	WQI
Nitrate (mg/l)	1									
Nitrite (mg/l)	0/272*	1								
Alkalinity (mg/l)	-0/216	-0/152	1							
Hardness (mg/l)	0/087	0/254*	0/354**	1						
Turbidity (NTU)	-0/152	0/162	0/271*	0/432**	1					
(EC sµ)	0/223*	-0/079	0/551**	0/293**	0/005	1				
(mg/l) DO	-0/002	-0/006	0/072	0/054	0/250*	-0/085	1			

pH	0/250*	0/256*	0/560**	-0/203	-0/385**	-0/259*	0/018	1		
BOD_5 (mg/l)	-0/040	0/031	-0/509**	-0/509**	-0/546**	-0/111	0/064	0/352**	1	
WQI	-0/026	0/099	-0/271*	-0/456**	0/171	0/098	0/083	0/387**	0/979**	1

** Significant at 1% level, * Significant at 5% level.

Discussion

WQI index was calculated using a set of parameters and their importance in scoring this indicator. As observed, the WQI index changes in different stations are almost uniform and only slightly increased at Station 10. However, significant differences were not observed between the different stations (p> 0/05). According to the table of categorizing indicators, stations 1 and 6 are located in very poor quality class and other stations were in the inappropriate one. In general, wetland water quality with an overall average of 329/72 is located on inappropriate class and is not suitable for human consumption, including drinking (Ramakrishnaiah et al., 2009).

WQI index changes in different stages of sampling indicated that, in general, the stage 1 to stage 4 (spring and summer), the index changes are additive and the step 5 to 8 (autumn and winter) process has been decreasing. As you can see, there were significant differences between the various stages of sampling (p<0/01). According to the table of categorizing indicators, the studied area is in 2 very poor and inappropriate quality classes (Ramakrishnaiah et al., 2009) and the use of that water is not suitable for human consuming and drinking purposes.

Among the factors in calculating the WQI, only the solved oxygen was opposite of the index and while increasing its volume, WQI index value decreases that were obvious in autumn and winter. Other factors have a direct relationship with WQI index. Of course, it should be noted that in the cold seasons, important parameters such as hardness, alkalinity, turbidity and conductivity have grown and of course, the numerical parameters should be increased. On the contrary, we see a reduction of the amount of indices due to the reduction of BOD5, particularly, and pH in water in these seasons that resulted in improving water quality from inappropriate to very poor. It seems that the reduction of BOD5 due to reduction in agricultural activities and entering less agricultural waste to wetlands in these seasons caused to lower the WQI index and better water quality in this season. We will discuss farther in this regard about the relationship between the parameters. In order to have an accurate view of the factors that cause poor water quality of sabzposhan wetland, the results obtained are discussed in this form:

Range of pH changing estimated from 7/44 to 10/45, indicating that the wetland is alkaline in nature. pH is a very important factor in determining water quality (Ahipathy and Puttaiah, 2006). The mean values obtained for pH (9/12) have shown the lack of consistency of pH with international standards for aquaculture (CCME, 2006, Lumb et al., 2002), standards of Iran, and the expression values for surface waters reported by Li in the range of 6/5 - 8/5(Li et al., 2009). The results show a positive correlation between the quality of water at 1% (WQI) and the pH. So as to increase the pH of wetland is reduced.

Mean 72/58 mg/lit of BOD5 is much higher than international standards and standards of Iran (WHO, 2004) and has reached to a critical state. If BOD5 levels of uncontaminated water are less than 3 ppm, then, it is the most important parameter in calculating the BOD5 Water Quality Index (WQI) and higher value in the region and has played a leading role.

The BOD5 level can be because of organic pollution in the area by who are there for fishing of tourism, or is because of the local contaminations (Kazi *et al*., 2009). BOD5 values, therefore, is likely to show contamination in the area so a long-term monitoring is needed. Also, the highest correlation between water quality parameters and WQI index at 1% is for this factor, which represents a significant role in the assessment of water quality.

Turbidity is also another important factor in the calculation of the WQI and water quality for human consumption. In this study, after BOD5, it ranked the second highest in importance among the factors that led to worsening conditions in the region. The values obtained from these factors, are more than limit and is incompatible with aquaculture standards and international and Iran standards (WHO, 2004, CCME, 2006, Lumb et al., 2002)

It should be noted that there is no correlation between these factors and WQI which is because of a reduction in value of the index WQI in the cold season, despite the increase in turbidity. Because in this season despite an increase in turbidity, reduction of BOD5 in the wetland could play a more effective role to reduce the index value.

The values obtained for dissolved oxygen in more times during the study period did not reach the critical conditions and water quality is good. As you can see, dissolved oxygen concentration mean of 9/31 ppm is in contingency with the fish Standards (CCME, 2006, Lumb et al., 2002) and international standards (WHO, 2004) and is adapted for human consumption (swimming , bathing and drinking) and is suitable for many aquatic organisms (Hammer, 1986, Wilcock et al., 1995). The amount of dissolved oxygen in the various stages of sampling and stations was high that one of the contributing factors of being them high in the pond water, is the presence of aquatic plants and photosynthesis (Li et al., 2009). These results are consistent with results from other sources of water in Iran (Zayandeh rood) and Iraq (Lake Dukan) (Alobaidy et al., 2010, Nemati et al., 2009).

The results showed that the EC is somewhat higher than the levels reported by the World Health Organization. The importance of electrical conductivity (EC) is due to the positive ions, large effects on the taste of water. It, therefor, has a significant effect on the acceptability of water to drink (Pradeep, 1998, WHO, 2004). EC, an indirect result of the dissolved salts and high electrical conductivity can be caused by natural weathering, sedimentary rocks, such as industry-specific or a human source or wastewater (WHO, 2004).

The results obtained in this study showed that hardness is often higher than what reported by the World Health Organization (200 mg) and in accordance with the standards of Iran (500 mg) it was good and lower than in the standard (WHO, 2004). Hardness is one of the important parameters for the quality of water used for domestic, industrial, agricultural and aquaculture is.

The values obtained for the alkalinity is much higher than reported by the World Health Organization standards and the standards of Iran (WHO, 2004). The increase in hardness and alkalinity are of those factors affecting water contamination and the calculation of the WQI. But as you can see there is a negative correlation between these factors and WQI index due to a reduction in the number of WQI in the cold season, due to the large reduction in BOD5 in the seasons.

The average nitrate in the wetland was equal to 0/865 mg/lit . Also, the mean nitrite of 0/038 mg/lit, has the lowest level of nitrogen compounds in the sabzposhan wetland that are accordance with global standards and Iran standards (WHO, 2004) and aquatic standard (CCME, 2006, Lumb et al., 2002). Therefore, the amount of nitrate and nitrite in sabzposhan wetland is suitable for aquaculture, drinking and other usages. One of the reasons for low levels of nitrate and nitrite in wetland water is the vegetation cover of the area, because the mineral composition of nitrogen can be absorbed by plants (Li et al., 2009).

Conclusion

Using Index WQI, sabzposhan wetland quality was assessed as unfit for human consumption and is not suitable for drinking. Also, some of the factors are inconsistent with the standards of the fish. Among the factors contributing to decline in water quality in the area is the organic contaminants and human activities and tourism in the region. Opacity and BOD5 are the most influential factors that exacerbate these conditions. Conducting ongoing and long-term monitoring can achieve better results and finally, in collaboration with the relevant authorities, can control health of these ecosystems to be managed properly.

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