RESEARCH ARTICLE

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Evaluation of River Water Quality using NSFWQI and GIS: A case study of Khorramrood River in Khorramabad, Iran

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Background & Aims of the Study: The use of qualitative indicators is one of the ways of water quality of river water. The purpose of this study is Khorramrood River of Khorramabad of water quality using water quality index (NSFWQI) and GIS that is a Geographic Information System.

Materials & Methods: In this cross-sectional study, qualitative parameters needed to calculate NSFWQI index that including pH, dissolved oxygen, total dissolved solids, biochemical oxygen demand, turbidity, temperature, phosphate, nitrate and fecal coliform six months of 2012 at six stations using were measured using standard methods. For River zonation was used GIS software.

Results: Results showed that the highest index of NSFWQI in the first station was observed 82 and the lowest was 42 in the sixth station. Average scores on the six months of the study was equal 58.05 and the river water quality based on the median of six months in the classes of water quality was average. The first station to the last station before going to more water pollution and the numerical values of the parameters are reduced.

Conclusions: Based on the average results of the study, the water quality was good at the first stations and the second, third, fourth was average, and was bad at fifth and sixth station. Indices studied by describing the state of water quality of sampling stations during the study period, it was provide the possibility of decision for the relevant authorities about how water is used in different parts of it.

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Background

Streams are the fraction of the waters. Despite this critical component of the hydrological cycle are the annual much water is transferred to the ocean (1). Rivers have particular importance as one of the most important sources of water supply and transport sectors of industry, agriculture and urban uses (2). Population growth and urban pollution from the discharge of sewage, industrial and agricultural waste disposal site leachate, surface runoff and contamination of water resources are limited (3, 4). Average rainfall in the country

averages about one-third of Earth's land and vast country so little precipitation distribution is not uniform. Therefore, surface water control and utilization of water resources is a high priority (5). Obviously, the quality status of water resources for appropriate strategies to prevent or reduce water quality improvement seems necessary. The zoning of pollution by GIS software makes any decisions about the management of environmental impacts must be taken with more knowledge (6). WQI is a very popular index for water quality classification. It is a comprehensive index of surface (4, 7-9). NSFWQI water quality criteria for the classification of commonly used indicators of surface water quality are based on the parameters, turbidity, temperature, phosphate, nitrate, fecal coliform, pH, DO, TS, BOD_5 is determined (10, 11). After measuring these parameters, each parameter is assigned a numerical weight or value of the index is calculated from the curves become finally, the mathematical equations used to calculate the final index. The NSFWQI index is decreases scale means with increase in water pollution make indicator decreases finally, the water quality conditions is grade very well, good, Average, bad or very bad (12). Samantray and colleagues were evaluated the water quality index of three rivers in the area of Paradeep in India in 2009 that were based on four quality parameters of pH, BOD_5, DO and fecal coliform that were measured in three different seasons of the year. According to the results of that, the water quality of Atarabanky Rivers often has been reported contaminated (13). The NSFWQI index has been introduced as convenient and practical quality index for river classification (14-15). Simeonov and colleagues examined the quality of surface waters in northern Greece that in the 25 studied stations were measured about 27 quality parameters monthly. The results showed that base on the distribution of pollution, the river pollution in the low rainfall month is more than of the rainy month. But the river pollution in general will not be decrease in the rainy month (16). Tahmasebi and colleagues have made sampling from 10 random stations for six months during the study of the years of 2010-2011. The results of this study have shown that the river water quality is located in the interval of the middle and poorer groups in all parts (2). Based on studies in Iran and other countries in recent years, the water quality index (NSFWQI) for monitoring and evaluating the quality of surface water such as rivers, lakes, ponds and tanks, this index are introduced as good, applied and best indicator of water quality indices (17-24). Khorramrood River, called "Gelall" in the native language, is part of Karkheh Basin and is originated from the northern heights of the city and the slopes of the Sefid Mountains and Kamarsyah Mount and is Located in the middle of Khorramabad city. Instead being the source of beauty and purity, nowadays its condition is completely catastrophic and unhygienic and threatens the health of local people. Unfortunately, no effective action has been taken in this regard yet. After passing through north villages, where it is used for agriculture, it enters the city and contaminates the water with a lot of pollutants such as industrial and domestic waste water, agricultural pesticides, and fertilizers. Another use of water is for industry part and the Green Spaces of Khorramabad city. The total length of the river is 110 km with about 5Km passing through the city of Khorramabad (25). In this study, the Khorramrood River of the water quality is reviewed by using water quality index of NSFWQI and GIS. Depending on the degree of water quality in the different sampling stations, the Potential pollutant sources identified in subsequent studies or enforcement actions and appropriate measures to be taken there by a body or organization concerned.

Aims of the study: In this study, the Khorramrood River of the water quality is reviewed by using water quality index of NSFWQI and GIS. Depending on the degree of water quality in the different sampling stations,

the Potential pollutant sources identified in subsequent studies or enforcement actions and appropriate measures to be taken there by a body or organization concerned.

Materials & Methods

This study was a cross-sectional that was taken samples of 6 consecutive months and each month based on standardized methods and tests them. The numbers of sampling stations are 6 for each station is 9 qualitative parameters and test was repeated twice for each parameter.

Study location and sampling stations

Karkheh River Basin of Khorramrood River of Khorramabad in the northern part of the river basin and river drainage Kakasharaf southeast, it seems. These two rivers near the Strait of continuous output with the name of the river that passes through the middle of Khorramrood River of Khorramabad River flows Kashkan. After carefully studying by using map of the river, the general location of the river was marked with a scale of 1:50000. To determine the location of the stations studied, according to the aerial parts of the plant and location of pollutant in river and also due to the entrance of contaminants and the possibility of sampling the river water, Six sampling stations were determined that listed in Table 1.

Sampling

Sampling on the fifteenth of each month for six consecutive months during the summer and autumn of 2012, from the stations selected according to standard methods (26) book published Standard Method 2005, respectively. Harvesting, transport, storage and testing of samples were performed using standard methods. Parameters of the physical, chemical and biological testing includes: DO, pH, TS, BOD_5, turbidity, temperature, phosphate, nitrate and fecal coliforms, respectively. Temperature, conductivity, dissolved oxygen and PH in samples measurements was taken. The electrical conductivity and temperature using EC meter model AQUA-COND, DO dissolved oxygen meter machine model wtw Oxi 330/SET German, pH meter using pH measurements were made in Germany pH230 SensoDirect model. Turbidity samples were determined using a model 2100N HACH turbidity meter readings were made in Germany. Total solids (TS) samples using standard methods at 105 to 103 degrees Celsius Standard 2540 numbers were determined. BOD_5 samples using standard procedures and using model BOD_5 incubator (BOD II TRACK 2100) German HACH Company was read. Apparatus for measuring nitrate DR-5000 spectrophotometer, cadmium reduction method (method 8039 provided by HACH Company, Germany) was used in nine steps. Total phosphate using DR-5000 spectrophotometer, the ascorbic acid method (method 4048 provided by HACH Company, Germany) by standard method 4500-PE USEPA has approved the seven stages were measured. Fecal coliform standard membrane filter method using a strainer Millipore 0.45 Micron with Vacuum Pump Millipore and incubator to culture model IKA ® KS 4000 I control, in 100 ml of the sample was calculated.

Index (NSFWQI)

Supported by National Institutes of Health in America 1970, Brown et al reduced quality index based on a survey of a large number of professionals with diverse expertise in the field provided. Firstly, they were introduced 35 qualitative parameters and according to experts, about 9 parameter selected for quality indicators (27). For calculating this index, the two weight parameters and qualities parameters are involve in it that are shown in Table 2.

After the measured, by using converted curve or by using the related programs, the final amount of each sub-criteria of equation (1) is obtained. I_i in relation to the sub-criteria (quality parameters) and W_i is the weight coefficient of sub-criteria (28).

Equation (1) $$\text{NSF WQI} = \prod_{i=1}^{n} I_i W_i$$

Then by putting a value of index in the table of index rating) is determined by the level of water quality (Table 2). Finally, for prepare of the quality of river Zonation map using this index is used the five colors mentioned in Table 2.

Zoning maps and river

Firstly, the sampling stations were chosen and then were harvested with the GPS receivers Oregon550 model that was taken XYZ with UTM format. After removing of the coordinate, the final conversion on data was performed by the GIS software with providing output like GIS maps with format of point, the sample point of description table was updated in the next phase. (Figure 1)

Table 1: Overall condition of sampling stations along Khorramrood River of Khorramabad

Station name	Coordinates of the stations studied			
	Mark	UTM_Y	UTM_X	Height (m)
The river originates in the khorramrood Above the village of Robat Namaky	A	3722520	249106	1521
Lower than the Cham Chaghal village or Gorzayn	B	3726669	249472	1519
Lower than Sand Workshop, Mavlavi sand and Ghaleh Sangi Village	C	3716933	249692	1517
Into Khorramabad city under Bridge Shohadah	D	3708457	254345	1517
Output of Khorramabad	E	3704357	250803	1515
lower than Khorramabad Airport	F	3704173	247311	1513

Table 2: **The Classification of the Index (NSFWQI) based on the color and quality of numerical values**

The numeric value of the color index	The interpretation of the numerical value of the index	The value of numerical
Red	Terrible	0-25
Orange	Bad	26-50
Yellow	Average	51-70
Green	Good	71-90
Blue	Top	91-100

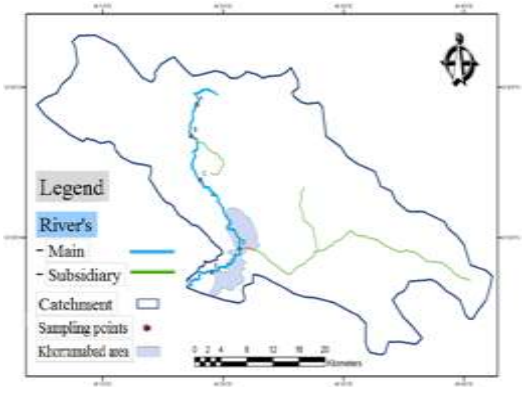

Figure 1: Location of sampling sites of Khorramrood River of Khorramaba

Results

The results of testing the quality parameters measured in this study to calculate NSFWQI is given in Figure 2 to 8. According to the above form, the highest concentration of total solids (TS) equal 1065 mg L in the Station Number Three in December and the lowest were observed and recorded of 620 milligrams per liter at station number one in November (Figure 2). The maximum and minimum of the river water temperature is equal 27.15° C in the station number three in August and is observe 6.25° C in the Station number one in December

(Figure 3). The high pH of the river water is observed at station number three in July equal 8.18 and the lowest PH observed at Station Number One in September equal 7.11 (Figure 4). The maximum amount of dissolved oxygen is 10.1 mg at station number one in December and the lowest amount of it is 4.21 mg at the station number six in August (Figure 5). The high rate turbidity of the river water is 295 NTU at Station number three in July and the lowest of it is 0.33 in the station number one in July (Figure 6). The nitrate concentration in the sampling stations, the highest rate is 151.73 mg at station number five in September and its lowest rate is 0.5mg at station in December (Figure 7). The total phosphate concentration at station number six in September is the maximum amount equal 3.928 milligrams per liter and took the least amount of 0.0685 milligrams per liter at Station number one in November (Figure 8). Most oxygen demand for biochemical (BOD_5) is 10.78 milligrams per liter at station number six in December and the lowest number of zero milligrams per liter were observed and recorded at stations number one in all months of sampling. The concentration of measured parameters in other months and the sampling stations are given in Figure 2 to 8.

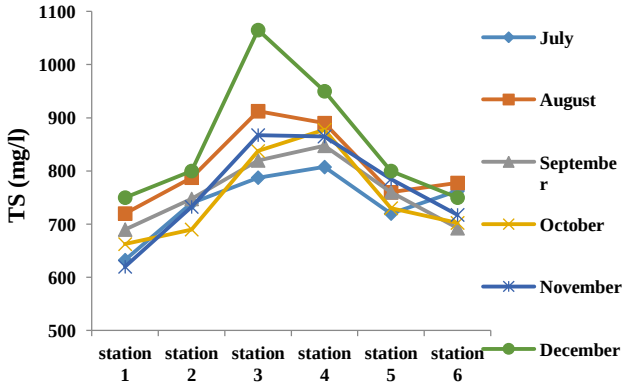

Figure 2: Variation of total solids in the studied stations

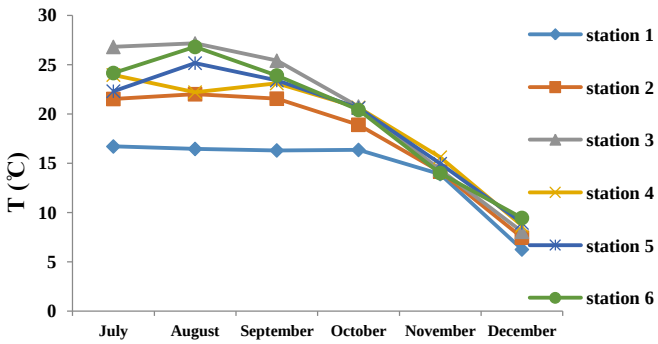

Figure 3: Variation of temperature in the studied mounts

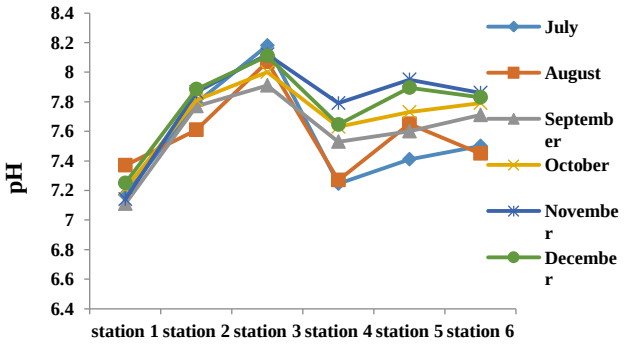

Figure 4: Variation of pH in the studied stations

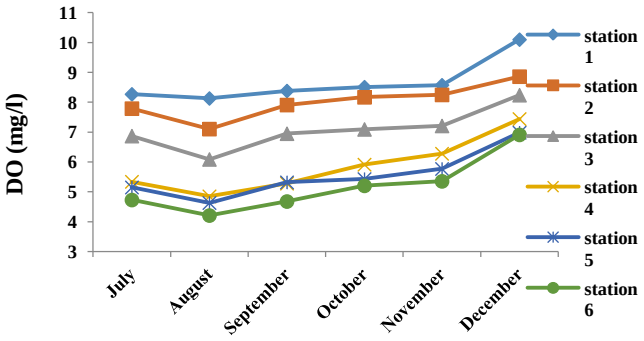

Figure 5: Variation of demand oxygen in the studied mounts

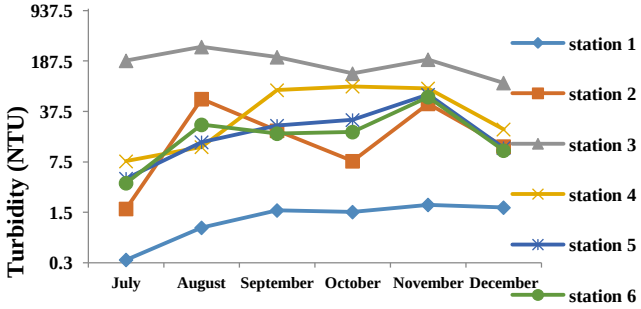

Figure 6: Variation of turbidity in the studied mounts

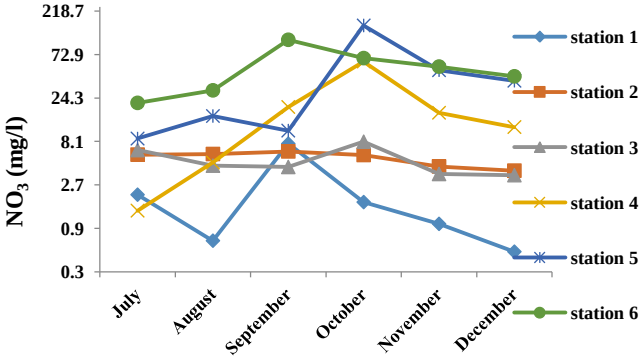

Figure 7: Variation of nitrate in the Studied mounts

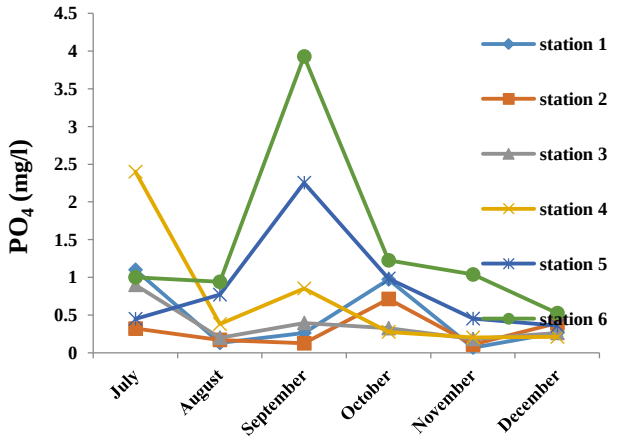

Figure 8: Variation of phosphate in the studied mounts

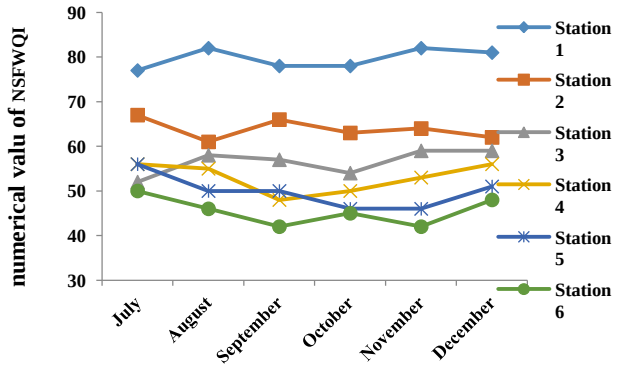

Figure 9: Variation of AWQI in the studied stations and months

According to the numerical value of NSFWQI index (Figure 9), was observed that among the studied stations, the station number one with the highest numeric value equal to 82 had the highest quality in August and November. Based on the classification, the water of this station was located the among the highest water quality. The worst water quality is at station number six in September and October with the numerical value of NSFWQI index is equal 42 that have been classified bad according to the categories of water quality. As we move from the first station to the last station, reduced water quality and the numerical value of the studied index has declined. The Mean of studied index have been good at the first stations in all months. The water quality Station is average in the second, third and fourth station and the water quality are poor in the fifth and sixth station. The Mean numbers of cases per month, in all months sampled, are in the range of average values. The river water based on the numerical Mean of index has been the average class of water quality in the months studied. Statistically can be seen that the qualitative parameters: Fecal coliform ($p<0.001$), Temperature ($p<0.001$), Temperature changes ($p<0.007$), Electrical conductivity ($p<0.001$) and magnesium ($p<0.015$), Significant relationship has shown with the stations under study. The relation of the rest of quality parameters was not significant with the stations sampled during the study period. Also the quality parameters: Dissolved oxygen, fecal coliform, pH, temperature, temperature, electrical conductivity and magnesium ($p<0.001$), total phosphate and calcium ($p<0.045$) and partly nitrate ($p<0.051$), had a significant relationship with the months sampled. With regard to BOD_5 parameters ($p<0.349$), cloudiness ($p<1.000$), total dissolved solids, with ($p<0.062$) and sodium ($p<0.143$) with the months sampled was not significant during the study period.

Khorramrood River of Khorramabad Quality Zoning is based on studies index and by the using of GIS is shown in Figure 10 to 12. Based on the above Zoning, the green color of the station number one in all months sampled shows river water in a good quality. River

water qualities in the second and third stations in all months are average. The lengths of the river are shown on the map with yellow color. The River Classes in the station 4 in September and October (Figure 11) has declined to bad water quality and is shown with orange color. However, the water qualities in the above station as well as other months are in the middle class and are shown in orange color. The Water quality at five stations in July and December (Figure 11 & 13) at average grade of water quality and shown with yellow color and the rest of the month was bad quality and is marked in orange. Water qualities at the last station (station number six) in all months placed in the classes have bad water quality and along of the river at this station are shown in orange on the map.

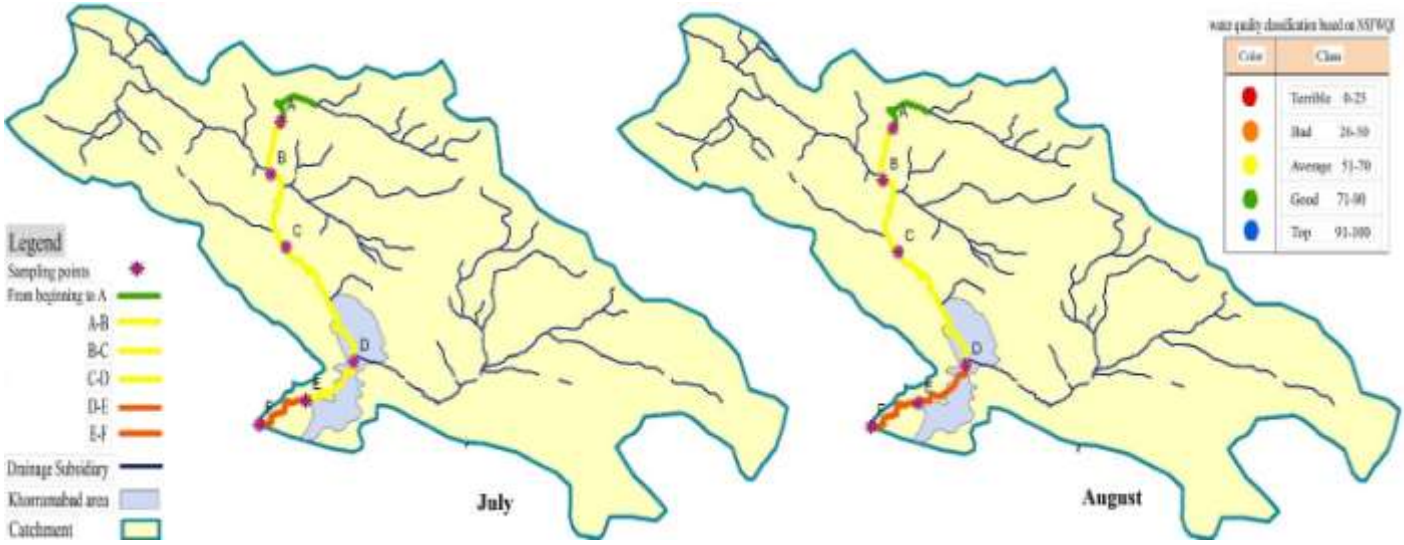

Figure 10: The Zoning of khorramrod river water quality based on the NSFWQI in July and August months

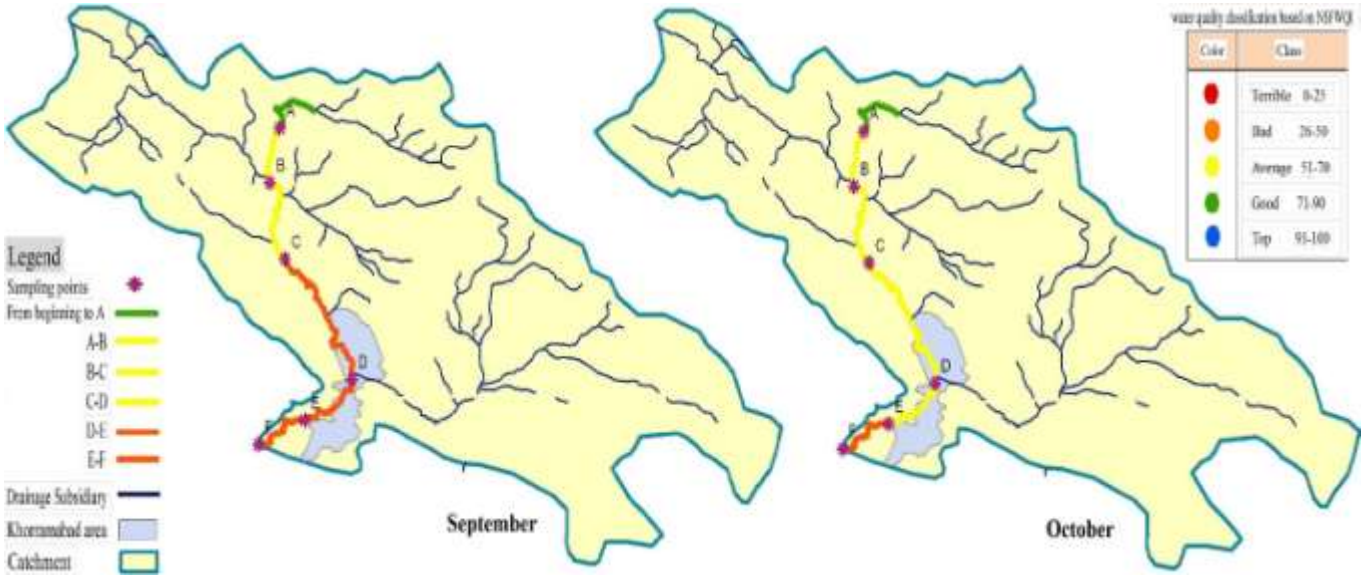

Figure 11: The Zoning of khorramrod river water quality based on the NSFWQI in September and October months

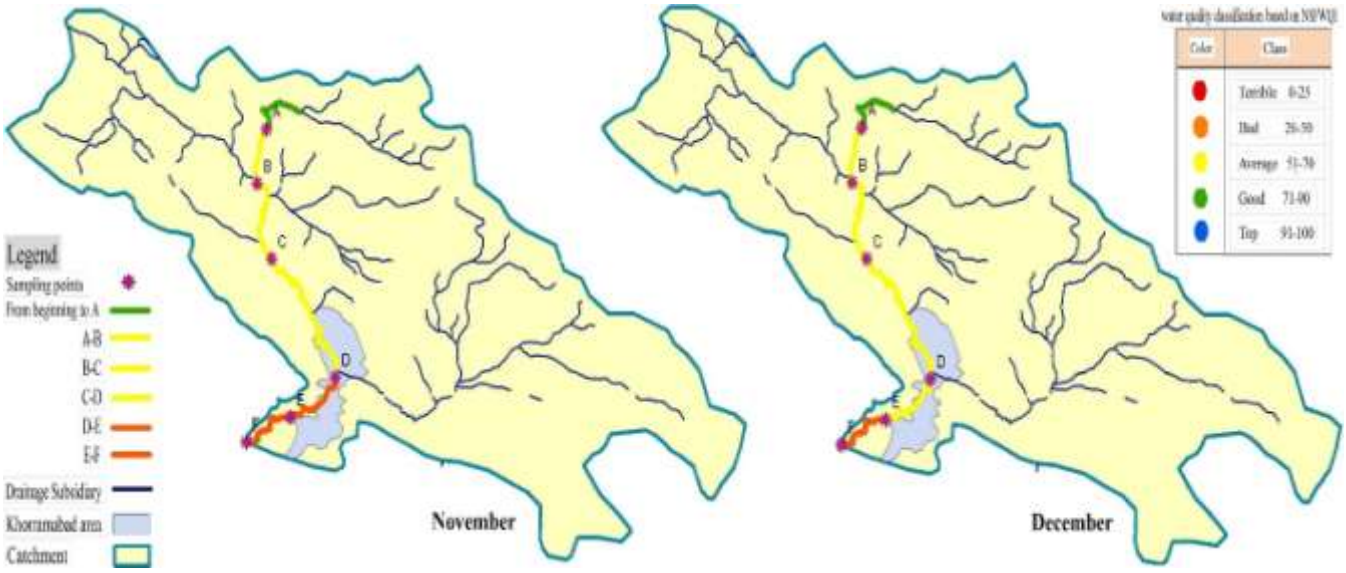

Figure 12: The Zoning of khorramrod river water quality based on the NSFWQI in November and December months

Discussion

Results of tests of quality parameters revealed that the quality parameters measured at the 1 station have been of the highest quality compared to other stations. This is due to the lack of human waste, industrial, agricultural waste and other polluting agents into the station. Water quality station numbers two and three are average in the all months. The reason of Decline in water quality in the second station are high concentrations of total dissolved solids is fecal coliform and BOD_5. Mirmoshtaghi and colleagues in 2011 showed that coliform contamination increases along the river from upstream to downstream stations that are in agreement with the results obtained in this study (29). Station number three factors in addition of those factors, increased turbidity caused by sand washing plant located at the upstream station and the pH is increased to a certain extent. The water quality in the station number four in September and October are bad and the rest of the months are average. The reason of decline in water quality in this station is illegally discharging sewage and trash into the river in the city of Khorramabad, the river and bridge construction activities and other human factors. Also Torabian and his colleagues in 2004 has stated that the reduction in the river water quality under the studies was the result of entering effluent of Industrial Complex around the basin (17). The river water quality in the station number five is average in July and December and is bad in the rest of the month. Important factors contributing to the decline of water quality are sanitation station, industrial and agricultural drainage from agricultural land is around them. The Water qualities have been bad in the station number six in all sampling months. The reason for this decline is Discharge of food Industrial Wastewater nearby river, Discharge of untreated sewage bypasses that related to the wastewater of Khorramabad city and also is agricultural drainage around the river. Norouzi et al in 2010, Similar to the results obtained in this study, the most important factor Diojin river pollution has created human factors (30). Jafari and colleagues in 2009, during the study concluded that the Municipal wastewater

treatment plant discharge the river water outlet is not only reduces water quality stations, but also will affect downstream stations (21). Also Mirzaei et al. the discharge of rural and urban sewage into the Jajrood River is as the most important factor of river water pollution (18). Nitrate and phosphate concentrations at station number five and six was high use of nitrate and phosphate fertilizers on nearby agricultural land. Nasir Ahmadi and colleagues in 2010 showed that high fecal coliform water was effective in reducing the number of parameters (27). The results of this study clearly demonstrated that the same issue. In all the months sampled at all stations studied, the concentration of total solids (TS) were high due to the geological conditions of the area and the river substrate domestic and industrial wastewater discharges into the river to be Due to municipal and industrial wastewater discharges at all stations except station number one, the number of fecal coliform and BOD_5 and dissolved oxygen levels are low. Dedicated to high value-weighted index of fecal coliform and dissolved oxygen for calculating NSFWQ index, and the high concentrations of total dissolved solids (TDS) in all stations and in all sampled months have the greatest impact on reducing the numbers of these NSFWQI parameters during the study period. Shahsavari Pour and colleagues also showed that pollution levels in the downstream river more than upstream (31). Also this situation was observed in the water quality of Khorramrood in Khorramabad. There was a strong linear correlation or linear coefficient of Pearson had the Quality parameters of dissolved oxygen of solution with temperature, and BOD_5 during the study period. In addition to the factors discussed before, Warm climate, low rainfall and river flow reduction during the seasons of study has been effective on the water quality of Khorramrood River. Bordalo and colleagues showed in Portugal that the water quality has declined significantly in the dry season ($p<0.001$) that correspond to the results obtained in this study (7). In this study, in the month of high river flow and river pollution is less; the rate of numerical of index under the studied is high. Also the results of Samadi study et al, Statistically show significant correlation (P-value<0.05) between the months of sampling and survey index (3). Consequently, these results correspond to the results obtained in this study.

Conclusions:

The results of this study show that the water pollution increased whatever we far from the source of the river to the last station. Discharge of domestic sewage, industrial waste, animal waste, urban and rural, agricultural drainage, warm climate and low rainfall and reduced river flow in the seasons examined are the main reasons for the decline in the river water quality at different sampled stations. Therefore, for maintaining the quality of water resources for future generations as well as public health, the following actions are recommended: Stricter enforcement of laws and regulations and instructions to prevent the discharge of sewage and garbage, urban and rural, livestock and animal waste-rural landowners adjacent to the river, Necessitated the construction of wastewater treatment industries to separate the industrial and municipal wastewater treatment plant operation and proper operation prior to discharge of sewage produced Khorramabad city into the figures blue (the river water, education the farmers that live near the river basin at the farming villages about harvest And proper use of water, fertilizer and chemical properties and the correct operation of agricultural land and Ultimately set the unit to provide oversight and monitoring of river water quality and quantity data banks and protection of water quality changes in different information for better decisions relevant authorities.

Footnotes

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Conflict of Interest:

The authors declare no conflict of interest.

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