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Water Quality Assessment Based on WQI and CWQI Indexes in Balikhlou River, Iran

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ABSTRACT

Rivers as one of the principal water resources used in different sections such as agriculture and industries and drinking water as well. Therefore maintaining acceptable quality of this resource, regarding recent droughts and urban and rural development is of important environmental concerns. With regard to the importance and vital role of the Balikhlou River in water supply of Ardabil province and receiving different pollutant materials, its quality monitoring is essential. In this research, two water quality including WQI(Water Quality Index) and CWQI (Canadian Water Quality Index) are used for water quality assessment of this River. The Value of each index is being studied seasonally during a period of two years. Using CWQI found that the water quality of the studied river ranked in Fair category while its quality for recreation, livestock and agriculture usage was ranked excellent in all stations. It was demonstrated in this research that the WQI is a general index to assess general quality of water. But CWQI is a proper index for determining water quality for different usage of drinking water, irrigation, aquatic and overall use and gives more precise and suitable information.
KEYWORDS: Water resource management, Water quality indexes, Water pollution, Balikhlou River.

1. INTRODUCTION

Human civilizations have always had a regard and demand of rivers and flowing waters for ages and have usually been founded near the rivers because of their demands of drinking water, hygiene, industry and irrigation use. During the time human activities had been changing the quality of these water sources [1].Different kind of urban, industrial and agricultural wastes had been loading to these resources as population growth and rural and urban society's development [1 and 2].

River water quality classification is the first and the most important step in surface water quality assessment for different consumptions including drinking water, industrial and agricultural usages. Identifying the source of pollution and contaminated areas will result in safe and hygienic exploitation of water for different usages [2 and 3].

Freshwater's monitoring is an essential activity in environmental management programs [4 and 5].One of the very simple methods of reporting water quality parameters, without statistical and mathematical complexity, is using water quality indexes. Water quality indexes are one of the best tools in water quality assessment and its management [6.7].Various techniques have been used for quality measurement of world surface waters, among which water quality indexes are one of the most popular and easiest in the word [8].The first step of surface water quality assessment, is recognition and selection of water quality parameters.

This index is a mathematical tool that summarizes numerous quality parameters with a single number. Comfort using and suitable classification of water quality is some of valuable characteristics of this method. Another index is Canadian water Quality index which was founded by the University of British Columbia. Using a large number of water quality variables for calculating quality index is one of the merits of this index.

Studied the Darehmoradbeig River in Hamedan province, in the west of Iran and classified its quality using WQI and GIS technology. The result of this study well shows the profitability of WQI in quality classification of rivers. This index can well present ecological impacts and discharging different pollutions into different section of the river, and enabled decision making about water usage in different sections [9].

Four water quality indexes, DSWQ, OWQI, NSFWQI and NSFWQI was Used in four stations in order to quality assessment of the Karkheh embankment dam in Khouzestan province in the south of Iran. Results of this study showed that the NSFWQI demonstrated quality variation of the Karkheh dam better than the other indexes [10].

Used WQI to assessment and classify water quality of the Talkheroud in north-west of Iran. Quality results of this research showed a discharge of pollution to the river [11].Studied using Geographical Information System in water quality classification of the Zohreh River during their research. Using ARC GIS software for quality classification of the river, and applying the option of different colors, a high quality classification was done and ultimately the whole river was ranked into four quality classes of good [12].

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Determined effecting parameters and quality map of the Humber River in England using the GIS. Results of this research showed that there are large variations for parameters in different sections, and these variations are affected by different factors such as waste water deposit, being near to coal mines, agricultural fields and applying different kinds of fertilizers and pesticides or tidal regions and transference of deposits and suspended solids [13].

In a research about quality classification of the Jajrood River, assessment the water quality indexation of the river using the water Quality Index was used. Water quality indexes used included NFS-WQI and WQI. The research showed that water quality of the Jajrood River decreases near populated residential cites due to an increase in the amount of microbiological parameters and suspending solids in water [14].

Due to existence of pollution recourses in the basin of the Balikhlou River and also different applications of the water for drinking water, industry and agriculture, this research has been conducted in order to water quality assessment and classification of the river in basin of yamchi dam.

Study Area

The Balikhlou River is located in the Caspian Sea watershed area. Permanent River with approximate 95 kilometers flow in province and its geographical location is in Ardabil city. River water application is in various sectors especially in water supply in department of agriculture and aquaculture their water requirement are 15 million cubic meters for 2000 hectare land under cultivation.

To get the required data for water quality assessment of the Balikhlou River, for stations, according to regional and non – regional contaminant recourses, are determined (Table 1.).

Table 1. Coordinate system situation of sampling stations on Balikhlou River

Station Position	x	Y
Yamchi Dam entrance	240219536	4215989525
Upstream of Nir	234689064	4209331481
Downstream of Nir	238340250	4215613668
Joorab chai	237964392	4217170791

MATERIALS AND METHOD

One of pollution assessment and quality ranging methods of rivers is using a quality index which shows compound effect of physic-chemical and biological parameters. There follows an explanation of water quality indices applied in this research.

1. Water Quality Index (WQI)

This index was formed by U.S. National Institute of Health for water Quality ranking in the early 1970s, considering nine quality parameters including fecal coliform, nitrate, total suspending solids, pH, phosphate, temperature, dissolved oxygen and BOD. These parameters do not have equal parts in index calculation and carry different weight factors depending on their degree of influence on water quality. Because of different measurement units of this parameters, each parameters effect on water quality has been expressed separately and quantitatively [15]. Using equation number (1), the national institute of health has formed this formulation water quality grading:

$$WQI = \sum_{i=1}^{n} W_i \times Q_i$$

In which WQI= Water Quality Index, Q_i= value of i parameter that is acquired according to relevant diagrams, W_i: weight ratio of i parameter (table1) and n= number of water quality parameters.

Table 2: Weight ratio of water quality parameters (WQI)

Turbidity	Phosphate	Total suspending solids	Temperature	pH	Nitrate	Fecal coliform	Dissolved oxygen	Biological oxygen	Parameter
0.08	0.10	0.07	0.10	0.11	0.10	0.16	0.17	0.11	W_i

After calculating the index using equation number 1 water quality can be ranked using table 3 [15].

Table (3): Water quality ranking, using water Quality Index (WQI)

Excellent	**91-100**
Good	71-90
Fair	51-70
Suitable or quite weak	26-50
Poor	0-25

2- Canadian Water Quality index (CWQI)

Canadian water quality index was founded in 1995 based on water quality index, released by British Columbia University. A merit of this index is using numerous quality variables for calculating this index, though it has some limitations as well.

In this research the version of CWQI 1.0, programmed using Excel and visual Basic software's (last reviewed in June, 2005) has been used [16].Input data for this modeling consisted of 38 parameters; "Temperature, Color, Electrical Conductivity. Turbidity, k, Mg, Na, Ca, PH, DO, Sulfate, Chloride, fluoride ,P,COD, Nitric acid, Cu, Cr, Co, Cd ,Be, Ba, As, Al, Si, N, V, Sr, Se, Pb, Ni, Mn, Li,Hg, Fe and Zn."

Canadian water Quality index is calculated using three leading factors:

F_1,F_2,F_3 ,$F_1$and F_2 factors are usually calculated directly but some extra steps are required for calculating F_3.

F_1 = (Scope): This factor represents the percentage of variables that do not meet the objectives at least once during the period (failed variables) and is calculated as follows:

$$F_1 = \left(\frac{Numberoffaildvariables}{Totalnumberofvariables}\right) \times 100$$

F_2 = (Range): This factor represents the percentage of individual tests that do not meet the objectives (failed tests) and the formulation is as follows:

$$F_2 = \left(\frac{Numberoffaildtests}{Totalnumberoftests}\right) \times 100$$

F_3 = (Range): This factor represents the number of failed tests that do not meet their objectives. F3 is calculated in three steps:

1. The number of items by which an individual concentration is greater than (or less them, when the objective is a minimum) the objective. When the test value must not exceed the objective:

$$excursion_i = \left(\frac{Failed\ test\ value}{objective}\right) - 1$$

2. When the test value must not fall below the objective:

$$excursion_i = \left(\frac{objective}{Failed\ test\ value}\right) - 1$$

3. The collective amount of excursions that are out of compliance is calculated by summing the excursions of individual tests and dividing by the total number of test.

$$nse = \frac{\sum_{i=1}^{n} excursion_i}{Number\ of\ tests}$$

Steps of calculatingF_3:

After doing an above -mentioned steps, F3 factorcarries a value between 0 and 100 that is calculated withthis formula:

$$F_3 = \frac{nse}{0.01\ nse + 0.01}$$

The Canadian water Quality index is then calculated as:

$$CWQI = 100 - \left[\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}\right]$$

Ranking of water quality based on this index is as in table 4.

Table 4: Calculated quality index of Balikhlou River based on 2-years average.

CWQI	Ranking	Comment
95-100	Excellent	No need to purification
80-44	Good	As light need to purification
65-79	Fair	Needs purification
45-64	Marginal	Needs plenty of purification
0-44	Poor	Almost always needs purification and is in dangerous region

RESULTS AND DISCUSSION

The physical and chemical parameters including: Acidity, Dissolved Oxygen, Water Temperature, Turbidity, Electrical Conductivity, Biological Oxygen Demand. Total Dissolved Solids, Phosphate, Nitrate, Fecal Coliform, COD, Nitric Acid, Cn, Cr, Co, Cd, Be, Ba, As, Al, Si, N, V, Sr, Se, Pb, Ni, Mo, Mn, Li, Hg and Fe were sampled in specific stations during four seasons between the years of 2007 and 2008(Table 5).

According to calculations of water Quality index it is decided that the best water quality is for stations Nir upstream and Lai River and the poorest for stations 1 and 3. The downstream station possessed poor water quality due to passing through the city of Nir and discharge of urban waste water and aquaculture waste water.

Table 5: 2-year average amount of water Quality Index calculated scores of the Balikhlou River

Station code	pH	PO_4	PO_3	BOD	TURBI	Coliform	DO	TDS	WQI
Nirentrance	87	49	63	60	64	66	8	83	52
Nir upstream	64	66	89	68	72	54	5	82	57
Down stream	87	54	56	61	58	54	5	84	53
Joorab Chai	91	65	68	65	66	50	5	83	56

According to the results of WQI the water quality of the Balikhlou is ranked fairly poor in stations 1, 3 and fair in stations 2 and 4(Fig.1).

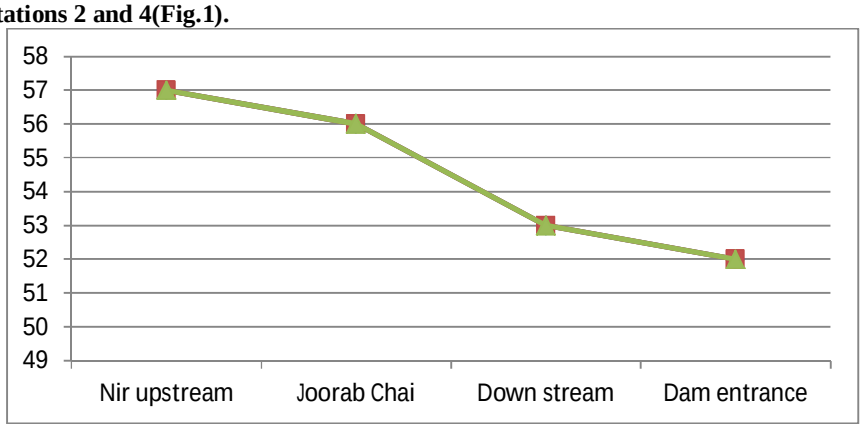

Fig. 1: Water Quality Variations of the Balikhlou River According to WQI during the years of 2007 and 2008.

The analysis of water quality of the Balikhlou was conducted using the CWQI software, as well. According to results obtained by the software, water quality of the first station in Nir upstream is ranked 57 for overall use and is in marginal conditions and needs much purification. The score obtained for drinking water use is 50 and is in marginal region and needs plenty of purification. Based on this index, the river is ranked 100 for recreation and livestock use and is in excellent region (Fig. 2).

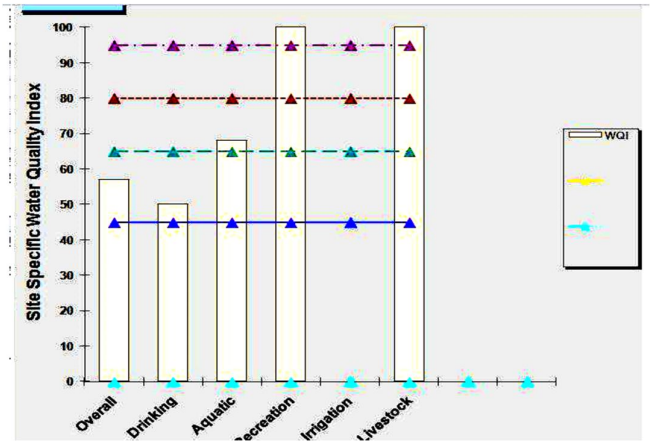

Fig. 2: Water quality ranking of Nir upstream using the CWQI

The results obtained for Joorabchai station show a rank of 54 for overall consumption and marginal and dangerous region according to CWQI ranking and need much of purification. The score for aquatic use is 66 and in fairly good region and needs purification.100 score got for livestock use in excellent region and with no need to purification (Fig. 3).

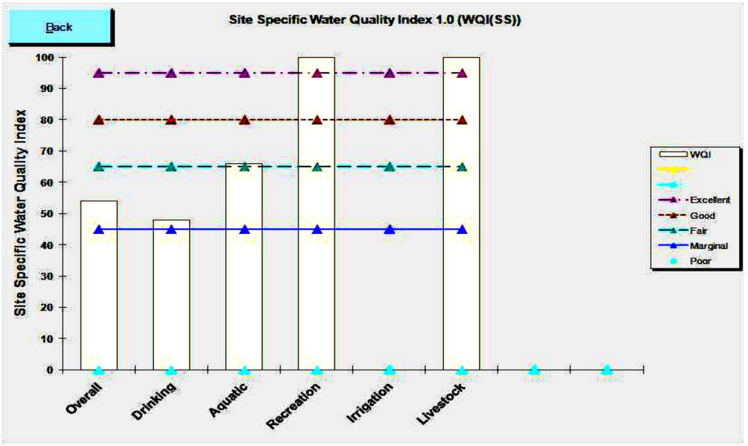

Fig. 3: Water quality ranking of Joorabchai using the CWQI

The results for Nir downstream show that according to the CWQI, it has a score of 47 for overall use and is in marginal and dangerous region and needs much of purification. The score for drinking water consumption is 43 and poor and alarm area. For aquatic use, the score is 67 and in fairly good region and needs purification. 100 for recreation and livestock use and in excellent area (Fig. 4).

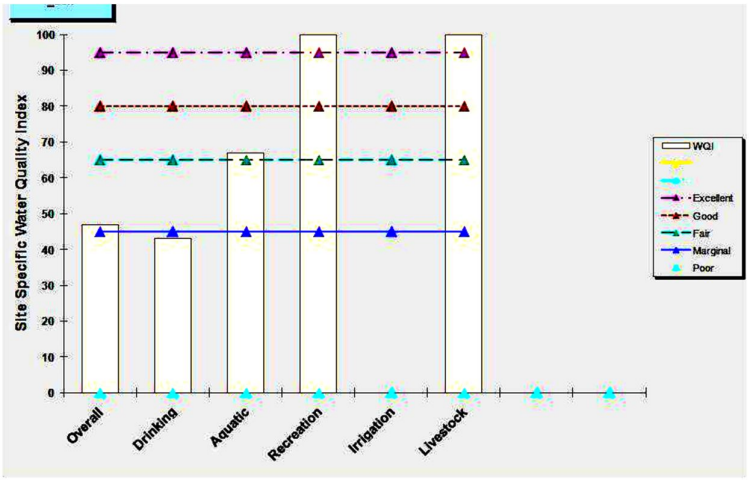

Fig. 4: Water quality ranking of Nir downstream using the CWQI.

According to Canadian water Quality index, water quality in the entrance station of the Yamchi dam is ranked 46 for overall use and is in marginal and dangerous region and needs much purification for drinking water supply, the score is 42 and is in poor region. For aquatic use, the score is 67 and is in fair region. For recreation and livestock use, the score is 100 and in excellent region (Fig. 5).

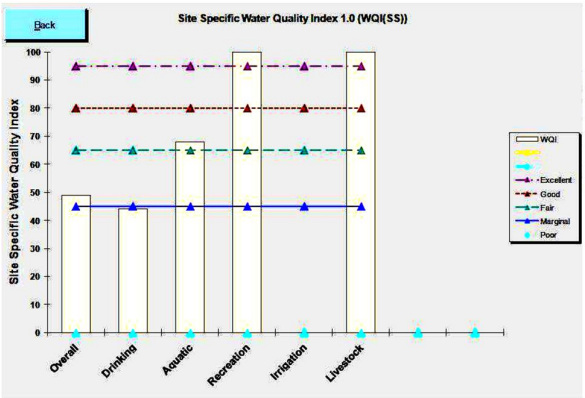

Fig 5: Water quality ranking of yamchi dam entrance using the CWQI

Comparing the CWQI results in four studied stations (Fig. 6) water quality of these stations is generally in excellent region for overall and recreation use and in fair region for aquatic and livestock use, but it needs purification as drinking water.

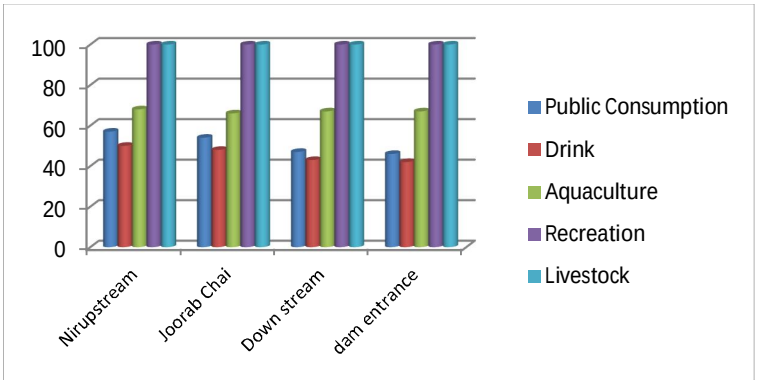

Fig. 6: Water quality comparison in studied stations using the CWQI

Conclusion

Water quality of all stations is ranked fair the WQI software. So that, the number obtained for Nir upstream 57,for Joorab station was 56 that have the best quality. For entrance station of the Yamchi dam was 52 and for Nir station was 53. The low water quality at these stations because it passes through the Nir city and received that sewage without wastewater plant. Quality condition of the stations is ranked excellent using CWQI for recreation, livestock and irrigation use in all stations. The best water quality condition for aquatic use is for Nir upstream station and the worst for entrance station of the Yamchi dam. Regarding drinking water consumption, the Nir upstream station possesses the best condition and along with downward flow of river and getting contaminants, the quality decreases. The results show that for the ranking quality of river water, WQI index is a more appropriate indicator than the CWQI index. Also, the results of this research coincide with the results of Samadi etal., and Hasanpour and Fataie studies.

Suggestions

Based on the results of this study to control and reduce water quality Balykhlv following is recommended:

1- Construction of municipal and industrial wastewater treatment plant of Nir city and standard discharge to surface water.
2- Entering the aquacultures waste water effluent monitoring with EPA standards for surface water discharge.

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