INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 3, No. 12, p. 258-264, 2013

RESEARCH PAPER OPEN ACCESS

Qualitative and quantitative investigation of Dez River water from the reach of Dez Dam to meeting point of Karun using NSFWQI index

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Key words: Mazandaran province, NSFWQI index, Dez River water, Dez Dam.

doi: http://dx.doi.org/10.12692/ijb/3.12.258-264 Article published on December 18, 2013

Abstract

Dez River is one of the main branches of big Karun River which passes mountainous regions of Lorestan province before entering Khuzestan province. This river passes northern and middle areas of Khuzestan plain and joins Karun River in a region named Band-e-Ghir. In order to determine and classify water quality of Dez River, 9 sampling stations were determined. Sampling was done in autumn and winter in 2010. Then, seasonal quality index of autumn and winter for each station was determined using water quality index system based on curves and tables of water quality index in America; then, different stations were classified along the river pathway. Physicochemical parameters of the river water such as DO, BOD_5, PH, TDS, nitrogen, phosphorous, turbidity, temperature and coliform were measured and then were investigated using NSF and GIS. Classification of the study stations based on water quality index system NSF showed that in autumn, station (1) has the maximum amount of quality index and station (6) has its minimum. In winter also, station (1) has the maximum and station (7) has the minimum amount of quality index. Also comparison of BOD, COD, PH and turbidity in the entire study period with standards of World Health Organization (WHO) demonstrated that, BOD and PH of all stations are standard. Turbidity of stations 1, 2,3,8,9 was standards and the rest of stations were higher than standard value. By comparison of the results of this study with similar conducted studies on other rivers in various countries and inside Iran, it can be concluded that, mean water quality of this river is lower than Malaysia and the U.S. rivers. Also, comparison of this river water quality with Indian rivers showed that, water quality of Dez River is higher than some Indian rivers and is similar to some other rivers in this country. Also, comparison of this river water quality with Tajan River which is located inside Iran showed that, mean water quality of Dez River is lower than Tajan River in Mazandaran province.

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Introduction

Entrance of various wastewaters to used water resources has adverse effects on these resources and makes their use difficult. Entrance of industrial wastewaters causes aquatics environment to be polluted as well as to disturb existing ecological balance in the water. Rivers are obtainable and available water resources. Fresh and healthy waters of these rivers enter these rivers after being consumed in urban and industrial regions a human and industrial wastewaters and sometimes without passing treatment stages. Therefore, this lifeline is attacked by various pollutants. Currently, about 90% of the world freshwater is supplied by rivers.

Currently, many countries including developed countries are faced with water shortage issue. Iran also is faced with such crisis and water resources shortage is a characteristic of countries like Iran. In an investigation conducted by Mehradi *et al.,* (2000) entitled: qualitative investigation of Tajan River and determination of industrial, agricultural and urban development on it, mean amount of BOD was minimum 18 and maximum 25.25 times of standard limit, also total amount of coliform was minimum 2.3 and maximum 60 times of water quality standard. Also, in a research plan entitled "maximum river organic load program" conducted by Environment Agency of America in 1991 on the lower part of Minnesota River. The major part of pollution of this river was determined as fertilizers, pesticides, oil, grease and toxins. At least 860 million m^3 surplus agricultural water is discharged annually into Dez River through river marginal lands drainage.

Discharge of industrial and agricultural effluents attached with human effluent from cities and villages adjacent with Dez River have caused the river environment to be exposed to risk.

Statistics show that, currently 75% of discharge of this river is formed by chemical, industrial and urban effluent. Neglect of environmental issues has caused that, Dez water which is one of the largest rivers of Khuzestan, loses its physical and chemical traits at downstream points, and the aquatics in downstream lose their fisheries value. According to the presented information and with regard to the importance and role of Dez River in Dez and Karun catchment and supplying required water for various sections (drinking, industry, agriculture, etc.) in Khuzestan province and consequently in the country (Iran), investigation of this river and determination of its qualitative class in different stations based on water quality index curves is the main objective of this research and can be applied as basic data to manage this valuable water resource.

Materials and methods

Study area

Study area is from Dez River to the connection point to Karun (about 120 km). Total length of the river is 515 km. Mean annual temperature and mean annual precipitation of the study area is 23 ^{0}C and ... mm respectively. In terms of geology, the considered area is located in hills area with 150-900 m height. The lands in study area are mostly dedicated to agricultural, industrial and residential uses, and are cultivated due to closeness to Dez River and proper conditions for agriculture. This river has permanent water and its water regime is snow-rain.

Study method

In study of surface waters if instantaneous and periodic sampling methods are used to monitor water quality, determination of sampling stations and qualitative measurement of water will be necessary. After field visits and investigating the topography of study area, 9 sampling stations were determined.

Sampling time and the number of samples

Sampling was carried out in autumn and winter in Dez River. In order to increase accuracy in statistical calculations, three samples were taken from each station during the sampling time, and the taken samples were used to measure following parameters:

1. The first sample for BOD_5 measurement
2. The second sample for COD measurement

3. The third sample for measuring other physic-chemical parameters.

Temperature and DO were measured at the location. Ultimately, 30 samples were taken for each stage from study stations to measure concerned parameters, and then they were transported to the laboratory.

Preparation of sampling containers

Sampling containers were plastic polyethylene according to standard guidelines. In order to prepare the containers, they firstly were washed by a kind of washing diluted liquid, then, they were pickled by sulfuric acid, and finally they were washed using distilled water without ions.

Stabilizing and transporting the samples to laboratory

Samples of physic-chemical experiments and BOD were kept near ice under 4 ^{0}C. In order to stabilize COD samples and stop bacterial activities in the samples, 1 ml concentrated sulfuric acid was added for every 1 liter of sample. The name of station, sample and sampling date were written on all the containers. Also, the samples were prevented to be contacted with metal, rubber and galvanized tools during all sampling stages and their transportation to the laboratory.

Sampling and measurement devices

Temperature was measured by a mercury thermometer, and dissolved oxygen was measured by a portable DO meter named HANNA HI9142 made in Italy at sampling location. The other physic-chemical factors were measured in laboratory by related devices. With regard to the study subject, various tools and materials were needed to be used to achieve the study objectives. Used equipment in this research was classified into three sections including field, laboratory and computer sections.

Field equipment

Nansen bottle, portable DO meter model HANNA HI9142, mercury thermometer, vehicle, GPS, icebox.

Laboratory equipment

Beakers in various sizes, 250 cc and 500 cc flask, test tubes, filter paper (Whatman42), burette and its stand, Glass funnel, graduated cylinders in various sizes, 0.5, 1 and 2 L polyethylene containers, gas flame, plastic sucker, wash bottle.

Laboratory materials

Solution of potassium dichromate, solution of ferrous ammonium sulfate, silver sulfate, mercuric sulfate, concentrated sulfuric acid, concentrated ammonia solution, tin chloride (II), phenol, di-sulfuric acid solution, standard solution of phosphate, nitrate standard solution, Magnet tablets.

Computer equipment

In order to provide report, NSF WQI software was used. The following steps should be done to calculate NSFWQI qualitative index:

1. To provide qualitative data of parameters BOD5, TDS, PH, dissolved oxygen, nitrate, phosphate, turbidity, temperature, and fecal coliform
2. To calculate sub-index of each parameter from quality index curves

(Raw values of the parameters should be converted to sub-index and the sub-index of each parameter was calculated).

3. Determination of weight factor of each parameter considering the number of parameters which their qualitative data are available.

(According to the importance, each parameter has its specific weight in NSFWQI; so, each parameter was multiplied by suggested weight factor of NSFWQI in order to calculate final index. Weight factors of NSFWQI have been determined in Table (1.2).

4. Final index is calculated by the following equation:

$NSFWQI=\sum_{i=1}^{n} W_i I_i$

Where I_i is sub-index of each achieved parameter from base curves and W_I is weight factor of each parameter.

NSFWQI software

Experts of water qualitative affairs investigated 35 qualitative experiments of water and considered that, 9 factors DO, BOD_5, TDS, pH, Nitrate, Phosphate,

Turbidity, Temperature, and Fecal Coliform should be considered as index. Then, they graded water quality level from zero (the worst case) to 100 (the best case) based on raw data. After that, drawn curves were normalized to obtain weight curve for each parameter. Results of 9 parameters were compared to draw curve and Q-value. After calculating Q-value, the parameter is multiplied by a weight factor (based on the importance of in determination of water quality) based on the importance of the parameter in water quality. For instance, DO have a high weight value (0.17) since; it has a higher importance in determination of water quality compared with other factors. Then, resulted numbers are summed to determine WQI (Water Quality Index).

If less than 9 tests is done, WQI can be achieved from other results and then, numbers adjustment. For example, if BOD and temperature are not available, the results of 7 other test are summed and WQI is calculated relative to the sum of the 7 weight factors. Also, if F.C is not done, its Q value is achieved from the average of DO, Nitrate and Phosphate tests (Water-research.net /water qualinedex/ water quality index. htm, (online)).

Results

Comparison with standards of World Health Organization (WHO) and Environmental Protection Agency (EPA) of America

Comparison of the amount of BOD, COD, pH and turbidity in different studied stations and seasons with standards of World Health Organization (WHO) and Environmental Protection Agency (EPA) of America.

Table 1. Name and number of laboratorial methods used in the study based on standard methods.

Number	Parameter name	Number of method	Method name
1	Dissolved oxygen	4500-O	Modification method by Azide
2	Biochemical oxygen demand	5210-B	BOD5
3	Biochemical oxygen demand	5220-B	Open reflux method
4	pH	4500-H+-B	Electrometric
5	Total dissolved solids	2540-C	Determination of dissolved solids in 180 ^{0}C
6	Phosphate	4500P-D	Colorimetric method using tin chloride
7	Nitrate	4500-B-C	Optical spectroscopy methods (volume measurement) with alloy Dovardo
8	Ammoniac	4500-B-C	Optical spectroscopy methods (volume measurement) with alloy Dovardo
9	Turbidity	2130-B	Nephlometry

Table 2. WQI (Water Quality Index)

Factor	Weight	Quality Index
Dissolved oxygen	0.17	
Fecal coliform	0.16	
pH	0.11	
Biochemical oxygen demand	0.11	
Temperature change	0.10	
Total phosphate	0.10	
Nitrates	0.10	
Turbidity	0.08	
Total solids	0.07	

Calculation of water quality index

In this section, conducted calculations of water quality index for studied stations have been presented in Table 6.

Discussion and conclusion

Comparison of the results of this study with similar studies inside and outside Iran

Comparison of the measured parameters based on the standards of WHOM and EPA shows that, BOD and PH of all stations are standard. Turbidity of Dez, Abbasabad, Chanibieh and Aboltoyur is also standard and the rest of stations are higher than standard.

Comparison of parameter phosphate based on the standard of southwestern Asian countries shows a lower amount than the standard for all stations. Comparison of BOD based on standard of China and South Korea indicates that, BOD for all stations is standard but, this value is higher than permitted amount for stations Hafttapeh, Khamat village, Chanibieh and Aboltoyur based on standard of Thailand. This comparison based on the standards of India shows that, BOD is less than the standard in all studied stations.

Table 3. Range of WQI has been defined as below.

Water Quality Index Legend	
Range	Quality
90-100	Great
70-90	Good
50-70	Moderate
25-50	Suitable or relatively weak
0-25	Weak

Comparison of biochemical oxygen based on the standard of England demonstrates that, all stations except Chanibieh and Aboltoyur are placed in clear class. Chanibieh and Aboltoyur also are placed in relatively clear class.

By comparison of the results of this study with conducted similar studies on the other rivers in various countries inside and outside Iran, it can be concluded that, mean water quality of this river is less than the rivers of Malaysia and America. Also, comparison of water quality of this river with the rivers of I India showed that, water quality of Dez River is higher than some rivers of India and is almost same as some other rivers in this country. Also, comparison of water quality of this river with Tajan River in Iran showed that, mean water quality of Dez River is lower than Tajan River in Mazandaran province. In this study, water quality of Tajan River has been evaluated as suitable class according to the classification of water quality index.

Table 4. Statistical variations of water qualitative parameters in the whole study period.

Station 9		Station 8		Station 7		Station 6		Station 5		Station 4		Station 3		Station 2		Station 1		Station
Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Descriptive statistics
2.3	6.35	2	6	1.5	5.55	0.8	5.2	0	4.7	0.3	4.5	0	4.7	0.7	4.95	0.1	4.55	Nitrate
0.02	0.01	0.018	0.075	0.02	0.05	0.03	0.65	0.03	0.35	0.06	0.03	0.03	0.45	0.03	0.35	0	0.02	Phosphate
37	46.5	56	53	24	103	280	265	188	236	393	225.5	29.7	44.85	35	38.5	28	37	Turbidity
0.4	8	0	7.8	0.2	8	0.4	8	0	7.9	0.2	8.1	0.6	8.2	0.1	7.95	0.1	7.85	pH
0.3	6.85	1.3	7.15	0.1	6.95	1.8	7.1	1.9	7.55	0.2	8.4	0.3	8.4	0.6	8.3	0.6	8.3	DO
0.1	2.75	0.5	2.55	0.4	2	0.4	2.4	0.4	2.2	0.2	1.6	0.1	1.95	0.2	1.8	0.2	1.7	BOD_5
1798	1254	2397	3253.5	8397	9338.5	622	29841	8377	32321.5	2586	3337	2575	3302.5	934	2000	893	1966.5	Coliform
62	591	144	838	88	567	85	407.5	424	551	56	347	2	342	3	321.5	29	179.5	TDS
3.1	18.25	2.4	18.1	4.1	18.25	5.1	17.65	3.2	16.9	4.3	18.05	1.6	217.6	1.1	18.35	1.7	18.35	Temperature ^0C

Considering the achieved results from table (1.3), it can be mentioned that: Nitrate: The maximum range of variations is in station 9 by 2.3 mg/l. Phosphate: The maximum range of variations is in station 4 by 0.06 mg/l. Turbidity: The maximum range of variations is in station 4 by 393 NTU. PH: The maximum range of variations is in station 3 by 0.6. BOD: The maximum range of variations is in station 8 by 0.5 mg/l. Coliform: The maximum range of variations is in station 7 by 8397.5. TDS: The maximum range of variations is in station 5 by 454 mg/l.Temperature: The maximum range of variations is in station 6 by 5.1 ^0C.

Achieved results from chemical analysis of the samples shows that, various factors affect water quality in Dez River pathway. Some important factors include: polluter industrial units existing in the river pathway and industrial effluent of these factories (Pars paper mill, farming and industry factories of Hafttapeh, Shoeybieh, and a part of effluent of Karoon farming and Industry) which enter the river, also, farm lands overflowing their drain water into the river, existence of various villages and counties along the river path and entrance of wastewaters resulted from these centers to the river. Considering these effective sources on the river water quality, the results of water quality index can be investigated. In this section, the results of calculating the water quality index are interpreted based on the mean of the data.

In upstream stations of the river (Dez dam reservoir, regulatory Dez dam, BisheAbbasabad,

BisheHamidabad), water quality status was relatively suitable while, in downstream stations (Hafttapeh, Khamat village, Bamdezh, Chanibieh, Aboltoyur), water quality had been reduces due to the existence of various contaminants mentioned above. Comparison of seasonal index of water quality in the studied stations shows that, water has had its worst quality in the autumn but, it was the best in winter due to increase of precipitations and dilution of pollutants. Also, this graph demonstrates that, the maximum amount of seasonal water quality index has been obtained in station of reservoir Dez dam in upstream and the minimum amount index was found in Bamdezh station due to the entrance of various pollutants and especially effluent of farming and industry of Karoon. According to the results of comparisons of water quality index between the stations and autumn and winter, Dez River can be divided into two parts. The first part includes Dez dam reservoir, Dez regulatory dam, BisheAbbasabad and BisheHamidabad in upstream of the river and before entrance of the pollutants, and the second part includes Hafttapeh, Khamat village, Bamdezh, Chanibieh and Aboltoyur in downstream of the river and after entrance of the pollutants which have an almost similar situation in terms of water seasonal index of water quality.

Table 5. Comparison of the measured parameters in the whole study period according to standards of World Health Organization (WHO) and Environmental Protection Agency (EPA) of America.

Environmental Protection Agency		World Health Organization		Station
PH(6.5-9)	Turbidity (75) NTU	PH(7-8.5)	BOD mg/lit	
Suitable	Suitable	Suitable	Suitable	Station 1
Suitable	Suitable	Suitable	Suitable	Station 2
Suitable	Suitable	Suitable	Suitable	Station 3
Suitable	Unsuitable	Unsuitable	Suitable	Station 4
Suitable	Unsuitable	Suitable	Suitable	Station 5
Suitable	Unsuitable	Suitable	Suitable	Station 6
Suitable	Unsuitable	Suitable	Suitable	Station 7
Suitable	Suitable	Suitable	Suitable	Station 8
Suitable	Suitable	Suitable	Suitable	Station 9

Table 6. Calculation of water quality index for the studied stations.

Winter period	Autumn period	Mean of the two periods	Station
67	64	65	Station 1
65	62	64	Station 2
64	60	62	Station 3
64	59	60	Station 4
58	52	55	Station 5
56	51	54	Station 6
54	53	53	Station 7
56	58	56	Station 8
57	54	57	Station 9

Table 7. Comparison of Dez River water quality with rivers inside and outside Iran.

Country	Water quality index value	River name
India	50-70	Cauver
India	25-50	Vrishabhavathi
Malaysia	66-87	Sg.Lagat
America	78.9-88.9	Oregan
Iran	47-70	Dez
Iran	80-95	Tajan

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