University of Birjand

Water Harvesting Research Vol. 5, No. 2, Autumn & Winter 2022, Case Study p. 160-167

10.22077/JWHR.2023.6001.1077

Evaluation of Water Quality of the Bahmaneshir and Arvand Rivers, Iran by the NSFWQI Index

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Received: 10 January 2023/ **Revised**: 2 March 2023/ **Accepted**: 7 March 2023

Abstract

Providing clean and suitable water for drinking, farming and living organisms in the ecosystem is essential. Therefore, qualitative assessment of water resources using qualitative indicators as one of the most suitable methods for managing water areas and having a regular program for water quality protection is essential. In this research, the quality of water from Shahid Bavi and Samen Al-Aeme Stations on the Behmanshir River and Dreifam Station on the Arvand River have been used by the National Institutes of Health (NSFWQI) index and using nine qualitative parameters such as turbidity, temperature, fecal coliform, phosphate, nitrate, PH, DO, TS and BOD. In the present study, due to the ease of calculation, the Water Quality Calculator software was used to calculate the NSFWQI index. After collecting data and performing the NSFWQI index analysis, the results of this study showed that during the summer and winter seasons in Shahid Bavi and Samen Al-Aeme stations on the Behmanshir River and Dreifam Station on Arvand River, the NSFWQI index for all months and mentioned stations were in the range of 25-50, which according to the standard classification table, this range of the NSFWQI index, indicates the weak quality of water in these rivers. Also, the EC index for all months and above stations was above the 2250, which indicates the bad status of the EC in these rivers.

Key words: Fecal coliform, NSFWQI index, TS and BOD, Turbidity, Water quality.

1. Introduction

Water is vital for life and all human activities, and access to safe, adequate and high-quality water is one of the most prominent conditions for achieving sustainable development. In the meantime, water resources and rivers are the most important resources of water supply that are used for drinking, agricultural, irrigation, industrial uses, etc. (APHA, 1992). The population of rivers is the most important problem of today's world, especially in developing countries that also Iran faces this problem with its four thousand years old civilization (Ibrahim pour et al., 2011).

Population growth and increasing human activities in the riverside basins and discharge of urban, industrial and agricultural wastewater, landfill leachate and also surface runoff has led to more contamination and limitation of water resources (Cude, 2001).

In this area, the measurement, analysis and interpretation of river quality data regularly allows that while using it in different cases, suitable management practices are to be adopted until gradually reduce the pollution of the rivers and move towards quality with acceptable standards (Mitchell, 2006). Many researchers have conducted research on the quality of water. Houshmand et al. (2009) studied the water quality of the Karun River in Khuzestan province for three years 2003-2005, and zoned the study area using the NSFWQI index. The results of this study showed that the water quality of the Karun River in the study area was classified as an average quality water. Enrique et al. (2007), studied the NSFWQI index and dissolved oxygen deficiency along the Guadarma and Manzanares Rivers for two consecutive years 2003-2001. Samples were collected from 16 stations and their results were reported seasonally. The results of this study showed that in the Guadarra River, the NSFWQI index has received good quality at the primary points to the average quality at the end points. The index value for the Manzanar River was also reported at about 65. Mirmoshtaghi et al. (2011) examined the qualitative and temporal trend of water quality indicators of the Sefidrood River, the highest quality index was Manjil dam with the value of 57 in February and the lowest value of this indicator was Tarik Dam in August 2011, which the amount 39 was allocated. The average NSFWQI index in the Sefidrood River is 47.5 and it is in the bad range qualitatively (Mirmoshtaghi, 2011). Considering that environmental changes are affected by the decrease or increase of chemical substances, the necessity of having a strategy and a program for preserving water resources and controlling their pollution is an important issue in management departments. Monitoring and controlling of surface water for its various uses is essential and necessary in order to provide consumers with suitable quality water for different uses. Water quality in aquatic ecosystems is assessed by physical, chemical and biological parameters (Saragoankar and Deshpande, 2003). In this research, water quality indexation method has been used to describe water quality in Arvand River as water suppliers in Abadan city. Among the various indicators used for this work, NSFWQI is used for simplicity and scope of application, as well as the availability of the required parameters has been selected.

The NSFWQI Index is owned by the National Institutes of Health of the United States, which was used by Brown and colleagues since 1970. Simplicity, efficiency and availability of its quality parameters are the benefits of this index. This index was used to determine the water quality of the rivers in question in this study (Derickvand and Faraji Sina, 2011). The average atmospheric precipitation in Iran is about one third of the Earth's average land, and in Iran, the distribution of the same amount of rainfall is not uniform. Therefore, the control of surface water and the use of water resources has priority. Obviously, determining the qualitative status of water resources seems necessary to take appropriate measures to prevent water quality degradation or improve it (Mitchell, 2006). In many countries, monitoring water quality is one of the main programs of water related organizations. For this purpose, in the case of Bahmaneshir and Arvand River in Khuzestan province, for the purpose of studying the parameters of quality as well as environmental impacts is considered.

The general objective of this research is to investigate the water quality of the Bahmaneshir and Arvand Rivers. The specific objective of this research is to evaluate the quality of the Bahmaneshir and Arvand Rivers in the summer and winter seasons, as well as to analyze the results of the research and compare them.

2. Materials and Methods

In this research, which is experimental, analytical and prospective, qualitative characteristics of river water of the Bahmaneshir and Arvand Rivers as water supply sources in Abadan city were studied in two seasons of summer and winter according to the national standard. In this research during one year and in two seasons of summer and winter, from three stations that as drinking water supply sources in Abadan city at different times and the following parameters are assessed and evaluated:

- Dissolved oxygen
- PH
- Total solids
- Biochemical Oxygen Demand
- Turbidity
- Temperature
- Phosphate
- Nitrate
- Fecal coliform

The number of samples is selected according to the quality control guidelines for water treatment plants, publication No. 318 of the Organization for Management and Planning of the country and the WHO guidelines, and the tests are based on the standard method of twenty-first published and samples are taken in special containers and To maintain samples, they are stored at 4 ° C until they reach the lab in the cold box (Karimian et al., 2006; Mirmoshtaghi et., 2011).

2.1. Water Supply sources of City

Bahmaneshir River**:** Bahmaneshir River is parallel to Arvand River and is 84 km long. The main source of drinking water and agriculture in Khorramshahr and Abadan is estimated. The river basin is estimated to be 4 to 6 meters (Shirdeli et al., 1999). Arvand River**:** An extensive river in the southwest of Iran with a width of 500 to 1000 meters and an approximate depth of 15 m. This river is from the rivers of the Tigris, Euphrates and Karun. This perennial river has a unique location with a significant amount of freshwater alongside the salty water source of Persian Gulf (Sabetahd Jahromi et al., 2013) (Fig. 1).

Fig. 1. Abadan city map and 3 stations studied in Abadan city

2.2. Procedure of conducting tests

2.2.1. Turbidity Measurement Method

Turbidity is an explanation for the optical properties that cause the light to be dispersed or absorbed before it passes through the sample (Saragoankar and Deshpande, 2003). The method is that the CELL is completely cleaned up. Before the measurement, the sample is shaken vigorously so that suspended material is suspended. Rinse the CELL several times with the samples and then, over the marked line of the sample. The outer surface of the CELL is completely cleaned with a clean cloth and the CELL is placed in the device and the turbidity is read in terms of NTU units.

2.2.2. PH Measurement Method

PH measurements are one of the most important and most applicable tests in water and wastewater chemistry (Simoes et al., 2008). In this method, PH of samples were measured by the WTW model of a digital table meter PH meter. To read the pH accurately, the pH meter was calibrated by a three-point method by tampon solution 4.7 and 10.

2.2.3. Temperature Measurement Method

The temperature of the samples was measured by the PH meter on the table of the WTW model.

2.3. Calculation of the NSF Water Quality Index

According to equation 1, the NSFWQI index is calculated from the sum of the product of the two factors, the weight of the parameter (W_I) and the quality of the parameter (Q_i). In this research, NSFWQI Calculator software is used to calculate the index accurately. By setting the value of each parameter in the software, the index value for each parameter is calculated and finally, by obtaining the mean values, the index is determined for each station or month. The parameters used, as mentioned above, include the temperature, dissolved oxygen, pH, turbidity, TS, phosphate, nitrate, BOD, and fecal coliform, the weight coefficients of each of which are presented in Table 2.

In this study:

$$NSFWQI = \sum_{i=1}^{n} W_i\, Q_i \qquad (1)$$

Table 1. Qualitative ranking and Pollution Interpretation of NSFWQI Indicators

Quality Classification	Numeric value of NSFWQI index
Very Bad	0-25
Bad	25-50
medium	50-70
Good	70-90
Excellent	90-100

Table 2. The weighting factor of each of the parameters

Parameter	Weighting factor
Dissolved oxygen	0.17
Fecal coliform	0.16
PH	0.11
BOD	0.10
temperature changes	0.10
Phosphate	0.10
Nitrate	0.08
Turbidity	0.07
Sodium	-

Table 3. Water quality classification based on EC

Quality	EC Value
Good	250-750
Medium	750-2250
Bad	>2250

3. Results and Discussion

In this section, the analysis of the data obtained from standard tests and related data is presented. 9 parameters including turbidity, temperature, pH, fecal coliform, phosphate, DO, TS, BOD and nitrate in the months of July, August, September, January, February and March, and for each month at three different periods of time and the mentioned stations were obtained and then the mean of the numbers obtained in these three time periods is used for analysis by the Water Quality Calculator software.

3.1. Analysis of data on Shahid Bavi Station on the Bahmaneshir River

Table 4 shows the data of the Shahid Bavi Station on the Bahmaneshir River, which has been carried out on the river for two seasons of summer and winter and three months each month (see Table 5) the averaging of these parameters is presented. The NSFWQI and EC indicators of Shahid Bavi Station have been compared in Fig. 2 and Fig. 3 over the 6-month period.

Table 4. Data related to Shahid Bavi Station on the Bahmanshir River

	July	Aguste	September	January	February	March
Turbidity	75	85	70	50	45	55
	77	82	73	48	46	58
	72	86	71	43	49	59
Temperature	18	16	25	44	39	35
	19	14	22	47	41	37
	21	15	24	43	40	37
EC	3723	2640	2460	3720	4000	3800
	3723	2640	2460	3650	4200	3900
	3870	2550	2800	3570	4250	4000
PH	7.69	7.57	7.45	7.78	7.81	7.75
	7.8	7.4	7.3	7.8	7.9	7.8
	7.7	7.4	7.5	7.8	7.8	7.6
Fecal coliform	570	510	540	670	550	420
	567	513	544	677	553	429
	572	511	541	672	550	426
Phosphate	1	0.3	0.2	1.3	5.4	7.5
	1.34	0.22	0.34	2.1	4.6	7.6
	2.3	0.15	0.19	0.78	1.2	5.8
DO	10.1	9.3	9.1	9.3	9	9.1
	11.1	9.5	9	9.5	9.1	9.3
	10.5	9.78	9.2	9.3	9.1	9
TS	558	582	1103	502	610	402
	547	629	988	533	677	417
	621	599	1225	522	549	426
BOD	6.8	4.1	4.3	5	5.8	6
	5.77	4.28	4.5	4.77	5.5	6.3
	6.5	4.41	4.5	5.28	5.9	6
Nitrate	7	4	6	8	8.5	10
	7.3	4.56	5.87	8.2	7.8	11.47
	7.21	4.77	6.68	7.88	7.88	11.1

Table 5. Average data for Shahid Bavi Station on Bahmaneshir

	July	Aguste	September	January	February	March
Turbidity	57.3	46.7	50.3	71.3	84.3	74.7
Temperature	36.33	40	44.67	23.67	15	19.33
PH	425	551	673	541.7	511.3	569.7
Fecal coliform	6.97	3.73	1.39	0.24	0.23	1.55
Phosphate	6.837	6.515	6.515	8.814	10.084	9.276
DO	415	627	519	1105.3	602	575.3
TS	6.1	5.73	6.02	4.43	4.26	6.37
BOD	10.56	8.2	8.027	6.18	4.44	7.17
Nitrate	3900	4150	3647	2627	2660	3564
EC	7.72	7.84	7.79	7.41	7.46	7.73

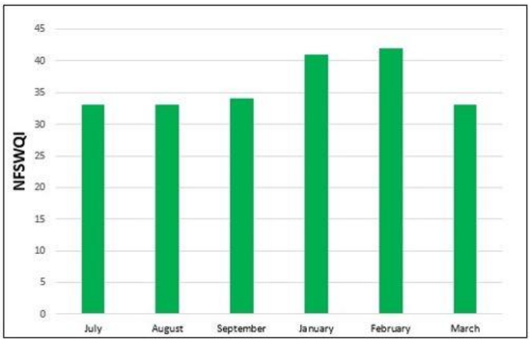

Fig. 2. NSFWQI Index diagram at Shahid Bavi Station on the Bahmanshir River

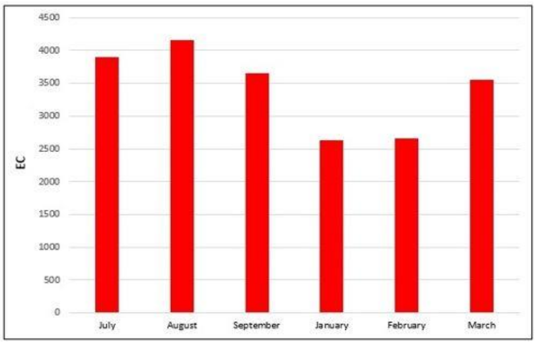

Fig. 3. EC Index diagram at Shahid Bavi Station on the Bahmanshir River

The results in Fig. 2 show that the NSFWQI index was maximum at Shahid Bavi Station from January-February, whereas the EC index was maximum from July-August as shown in Fig. 3. Despite this fact, the NSFWQI index in January-February was only one unit higher than that in December-January. Moreover, this index was almost the same in the range of 33-34 in other months. The lowest EC is observed in December-January and January-February, which was 2627 and 2660, respectively. Accordingly, water quality was lower in summer than in winter based on these two indices due to increased drainage water inlet and high evaporation losses in summer. Sallam and Elsayed (2015) studied a basin in Egypt and found higher water quality in winter than in summer.

3.2. Analysis of data on the Samen Al-Aeme Station on the Bahmanshir River

Table 6 shows the data on the Samen Al-Aeme station on the Bahmaneshir River, which has been carried out on the river for two seasons of summer and winter, and for each month, in three different periods per month (see Table 7) the averaging of these parameters is presented. The NSFWQI and EC of Samen Al-Aeme station are compared in Fig. 4 and Fig. 5 over the 6-month period.

Table 6. Data related to Samen Al-Aeme station on the Bahmanshir River

	July	Aguste	September	January	February	March
Turbidity	48	42	44	71	82	73
	53	41	39	73	79	77
	55	47	78	76	88	70
Temperature	38	41	39	19	18	22
	39	42	41	17	19	23
	39	44	38	20	22	21
EC	3600	39800	3500	2300	2520	2617
	3672	3848	32554	2520	2311	2729
	3721	4000	3721	2110	2547	2499
PH	7.4	7.8	7.8	6.9	7.1	7.3
	7.7	8.1	7.8	7.2	6.8	7.5
	7.2	7.9	7.7	7.2	7.4	6.8
Fecal coliform	411	497	631	507	531	577
	421	553	552	533	566	621
	388	421	410	522	547	561
Phosphate	3.7	5.21	1.1	0.4	0.5	1.2
	7.21	5.5	2.25	0.77	0.23	1.8
	7.43	4.32	1.41	0.65	0.49	1.69
DO	8.3	8.71	9.5	8.8	9.1	9.5
	8.1	9.1	10.1	9.3	9.1	9.33
	8.22	7.98	8.97	9.1	9.45	9.44
TS	398	599	621	884	921	577
	410	488	633	779	933	610
	432	610	648	910	954	628
BOD	5.7	5.5	5.2	4.5	4.81	7.1
	5.3	4.8	6.1	4.33	5.2	7.33
	5.9	5.92	4	4.5	5	6.42
Nitrate	9.5	8.1	7.65	5.3	5.88	6.54
	9.64	7.92	7.77	5.45	6.44	7.33
	10.11	8.41	7.9	4.77	5.1	6.1

Table 7. Average data for Samen Al-Aeme station on the Bahmaneshir River

	July	Aguste	September	January	February	March
Turbidity	52	43.3	43.7	73.3	83	73.3
Temperature	1	3	3	3	4	2
PH	7.43	7.93	7.77	7.1	7.1	7.2
Fecal coliform	406.67	490.33	521	520.67	548	586.33
Phosphate	7.31	5.01	1.59	0.61	0.41	1.56
DO	8.21	8.6	9.52	9.07	9.22	9.42
TS	413.33	565.67	634	857.67	936	605
BOD	5.63	5.41	5.1	4.44	5	6.95
Nitrate	9.42	8.14	7.77	5.17	8.81	6.66
EC	3664	3942	3492	2310	2459	2615

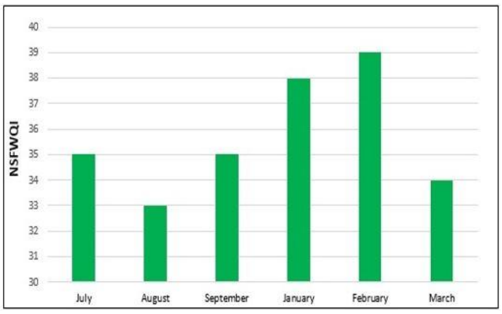

Fig. 4. NSFWQI Index diagram at Samen Al-Aeme Station on the Bahmanshir River

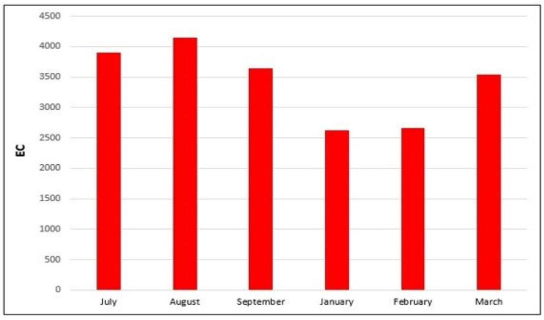

Fig. 5. EC Index diagram at Samen Al-Aeme Station on the Bahmanshir River

Table 8. Data related to the Dreifarm Station on the Arvand River

	July	Aguste	September	January	February	March
	113	105	65	50	27	75
Turbidity	145	135	75	75	70	90
	155	131	88	49	62	71
	39	43	37	17	17	21
Temperature	41	47	39	15	15	22
	45	41	40	19	15	20
	10200	9700	6300	2400	2500	2900
EC	10890	10600	7200	2700	3100	4800
	12500	11422	6890	3210	2890	4420
	8.7	8.1	8	7.5	7.8	7.6
PH	8.9	8.4	8.3	7.49	8.1	7.87
	8.6	8.5	8.5	8.7	7.6	7.44
	1011	1079	1420	1250	531	577
Fecal coliform	1057	1123	1580	1320	1118	1210
	1077	1149	1728	1180	1227	1270
	0.042	0.033	0.031	0.095	0.088	0.085
Phosphate	0.037	0.038	0.033	0.097	0.091	0.088
	0.046	0.03	0.035	0.088	0.095	0.091
	11.3	10.4	10.8	10.5	12.2	12.5
DO	11.5	11.6	11.3	10.58	13.1	13.4
	10.86	9.2	10.1	10.78	12.5	11.1
	1197	1050	1050	1100	1821	1930
TS	1267	1228	1428	1288	2100	1751
	1388	1245	1350	1220	1542	1300
	4.1	5.2	4.7	3.2	3.5	3.6
BOD	3.88	5.5	4.33	3.1	3.7	3.4
	4.3	5.1	5.1	3	3.6	3.8
	2.77	3.1	4.2	5.88	6.1	5.43
Nitrate	3.1	3.5	4.88	6.2	5.4	5.5
	3	3	3.8	5.5	6.9	5.6

Table 9. Average data for Dreifarm Station on Arvand River

	July	Aguste	September	January	February	March
Turbidity	13.77	123.7	76	58	53	87.7
Temperature	1	3	3	3	4	2
PH	8.73	8.33	8.27	7.56	7.83	7.73
Fecal coliform	1048.3	1117	1576	1250	1170.3	1244.67
Phosphate	0.0417	0.0337	0.033	0.093	0.091	0.088
DO	11.22	10.4	10.73	10.62	12.6	12.33
TS	1223.33	1276	1203	79.7	1641	1318
BOD	4.09	5.27	4.71	3.1	3.6	3.6
Nitrate	2.96	3.2	4.29	5.86	6.13	5.51
EC	11197	10574	6797	2770	2830	4040

As shown in Figs. 4 and 5, the NSFWQI index is maximum at Samen Al-Aeme Station from January-February, whereas the EC index is maximum from July-August. These results are similar to those found in Shahid Bavi Station. According to Figs. 4 and 5, when EC reaches its maximum value during July-August, the water quality index is much lower than in other months, which is reasonably acceptable. Like in Shahid Bavi Station, water quality in this station was lower in summer than in winter.

3.3. Analysis of data on the Dreifarm station on the Arvand River

Table 8 shows data on the Dreifarm station on the Arvand River, which has been performed on the river for two seasons of summer and winter and three months each month that in Table 9, the averaging of these parameters is presented. The NSFWQI and EC indicators of Dreifarm station have been compared in Fig. 6 and Fig. 7 over the 6-month period. As shown in Figs. 6, the NSFWQI index is maximum at Darifam Station of Arvand River in August-September, whereas the EC index is maximum during June-July, as shown in Fig. 7. Although water quality was higher in winter than in summer in Arvand River, the highest water quality was recorded in August-September in terms of the NSFWQI index. Although the NSFWQI in December-January, January-February, and February-March is lower than in August-September, they have lower EC.

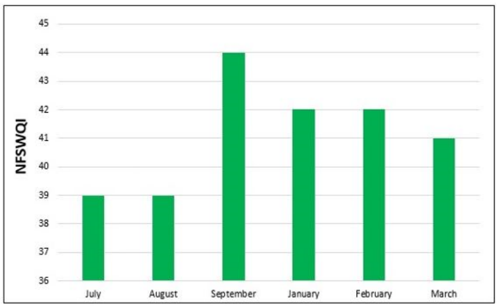

Fig. 6. NSFWQI Index diagram at Dreifarm Station on the Arvand River

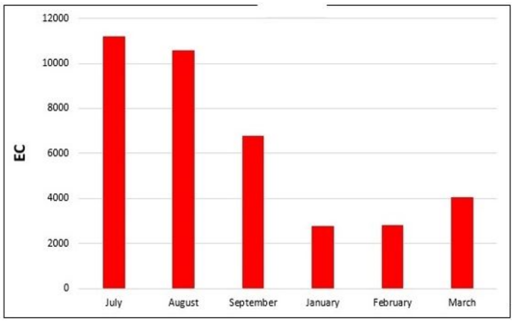

Fig. 7. EC Index diagram at Dreifarm Station on the Arvand River

4. Conclusion

In this research, the data obtained from the experiments and a collected data are classified and after analyzing the results, the NSFWQI index was obtained for the station Dreifarm, Samen Al-Aeme and Shahid Bavi during the summer and winter seasons. This index is determined according to the standard qualitative classification table given in Section 2. It should be noted that in this research, the EC index is also determined for the station and its scope is determined. According to the results of data analysis, in the three stations of Shahid Bavi, Samen Al-Aeme and Dreifarm in the months of July, August, September, December, February and March, the NSFWQI index was in the range of 25-50, which represents bad water quality in these rivers. Also, the EC index was evaluated at the three stations above 2250 which is classified according to the standard table in bad range. Water quality at three stations in the months of January and February is both NSFWQI and EC quality index relatively better and in the months of July, August and September were of lower quality. The three stations are relatively similar in terms of the NSFWQI index, but in terms of EC, the Dreifarm station has a much more unfavorable quality in the months of July, August and September.

5. Suggestions

There are several factors on the Karun River which can affect the water quality, including the entry and discharge of industrial, urban and agricultural waste without the necessary purification, discharge of urban and hospital wastewater without proper purification, according to the results. The following measures are required:

- Establishment of wastewater treatment plants at the site of urban wastewater discharge.
- Replacing and installing grids and rubbish, as well as timely replacement and filtering of filters at the outlet of wastewater from factories and agricultural land drains
- Change of agricultural pattern and irrigation methods and less use of chemical fertilizers and water saving due to the state of depression in the province.

6. Disclosure statement

No potential conflict of interest was reported by the authors

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