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AN EVALUATION OF WATER QUALITY FROM MOJEN RIVER, BY NSFWQI INDEX

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ABSTRACT

Water quality index (WQI) is valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment technique to meet the concerned issues. The aim of the study was to evaluating water quality from Mojen River by Water Quality Index based on National Science Foundation (NSFWQI). For this purpose, samples were collected from stations at up, middle and downstream of Mojen River in Semnan province (the biggest river in region) in a 2 years interval of 2013-2014 years. Nine parameters namely Turbidity, Biochemical Oxygen Demand, Dissolved Oxygen, Fecal Coliform, nitrate, pH, temperature, total solids and total phosphate were considered to compute the index. Our findings highlighted the deterioration of water quality in the river due to industrialization and human activities. According to NSFWQI, the best condition was recorded in the Darkhaniab (Upstream) and the worst condition concerned the Pole (Midstream).

Keywords: NSFWQI, Mojen, River, Pollution, Water Quality.

INTRODUCTION

Water, a prime natural resource and precious national asset, forms the chief constituent of ecosystem. Water sources may be mainly in a form of rivers, lakes, glaciers, rain water or ground water. The availability and quality of water either surface or ground, have been deteriorated due to some important factors like increasing population, industrialization and urbanization [1]. The first step for keeping river water quality and purification of polluted parts is obtaining information on the qualitative changes of river water in dimensions of time and place and also, determination of major sources and various water pollutants [2].

Water quality of any specific area or specific source can be assessed using physical, chemical and biological parameters. The values of these parameters are harmful for human health if they exceed the defined limits [3, 4, and 5]. Therefore, the suitability of water sources for human consumption has been described in terms of Water quality index (WQI), which is one of the most effective ways to describe the quality of water. WQI utilizes the water quality data and helps in the modification of the policies, which are formulated by various environmental monitoring agencies. It has been realized that the use of individual water quality variable in order to describe the water quality for common public is not easily understandable [6]. That's why; WQI has the capability to reduce the bulk of the information into a single value to express the data in a simplified and logical form [1]. Also, application of WQI specifies the process of variations and qualitative trends of water resources and also allows the classification of water quality (Brian O., Calculating NSF Water Quality Index, Wilkes University Center for Environmental Quality Geo Environmental Sciences and Engineering Department, Water Quality Index [7], National Sanitation Foundation

Water Quality Index (NSFWQI) [8], Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) [9], Oregon Water Quality Index (OWQI) [10] and Weighted Arithmetic Water Quality Index Method [11] are some of the important water quality indices used in water quality assessment.

Among various indexes which are applicable for water quality zoning, NSFWQI was selected because of its high precision, simplicity and availability of the required parameters [12]. It summarizes data in a single index value in an objective, rapid and reproducible manner [13].

According to previous studies, Mirmoshtaghi in 2011, studied the water quality of Sefidrood River by investigation of 20 samples at 5 sampling stations according to NSFWQI index and compared the results with OWQI index. The results showed that maximum and minimum values of NSF were 57 and 32, respectively. And the average value of NSFWQI along with Sefidrood River was obtained equals to 47.5, which is placed at bad region. Also, calculation of OWQI index showed the very bad quality of Sefidrood River during the study period [12].

In this study, classification of Mojen River's water quality in Semnan province (North east of Iran) is investigated by NSFWQI index.

MATERIALS AND METHODS

Study Area

Mojen River flows through a vast stretch with numerous perennial and non-perennial streams in the study area and forms a network of large and small rivers before joining the Gorgan Bay. The river is mainly used for fishing, propagation of wild life and irrigation. The Mojen at this stretch is classified as "Class B" as per the best designated use of water quality. Eighteen water samples from Mojen River were analyzed to assess the water quality of Mojen during the three seasons. The sampling location description of Mojen River are given in Table 1 and shown in Figure 1.

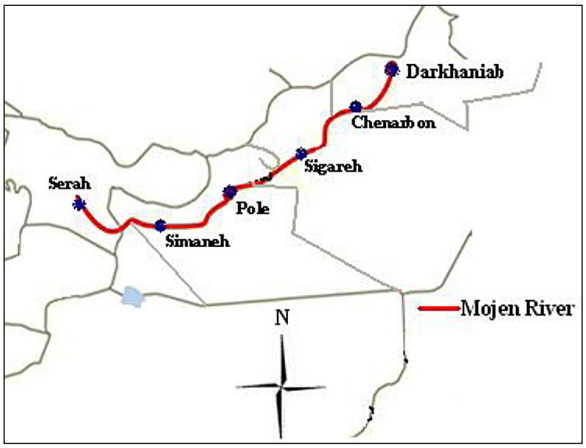

Figure 1. Studied area and sampling points

Sampling Procedure and Sample analysis

Samples were collected seasonally from stations at upstream (2 points), middle stream (2 points) and downstream (2 points) of in a 2 years interval of 2013–2014. The samples were analyzed using standard procedure [14, 15]. The pH of water samples was measured in the field. Samples were subjected to filtration prior to chemical analysis. The determination of TDS was done by a gravimetric process. The Winkler's method was followed for the analysis of DO and BOD. Nitrate was determined by colorimetric procedure. Fecal coliform population was analyzed by MPN/100ml method, by growing on M-FC medium at temperature 44.5° ± 1°C and counted after 48 hrs. Phosphate was determined by Ascorbic Acid Method. Turbidity was determined by Lenntech turbidimeter (LT 550).

Table 1. Sampling locations – Mojen River

Sampling No.	Location	Code	Description
1	Drakhaniab	M_1	The sampling location is near the bridge. The water is extensively used for irrigation.
2	Chenarbon	M_2	Sampling point is near the Chenarbon village. The main activity observed in the river is fishing.
3	Sigareh	M_3	Sampling point is at Sigareh village. The water is used for domestic purpose.
4	Pole	M_4	The sampling station is near the factory. The water is extensively used for irrigation and for factory process.
5	Simaneh	M_5	The sampling location is near the factory. The water is used for domestic usage like washing and cleaning.
6	Serah	M_6	The sampling location is at Serah village. The main activity observed in the river is irrigation and cleaning.

National Sanitation Foundation Water Quality Index (NSF WQI)

After measuring 9 of the above mentioned factors, each sub-index is obtained according to the conversion curves (appendix). The following equation (1) is applied for calculation of final index:

$$NSFWQI = \sum_{i=1}^{p} W_i I_i \quad (1)$$

where: I_i – the sub-index for i^{th} water quality parameters obtained from conversion curves according to Table 2,
W_i – the weight (in terms of importance) associated with i^{th} water quality parameter,
p – the number of water quality parameters [16].

NSFWQI index is a reduction index, namely it is decreases with increasing water pollution. This index has a value between 0 to 100 and is classified according to Table 3.

Table 2. Weight factor of NSFWQI

Parameters	Weighting factor
Turbidity	0.08
BOD	0.11
DO	0.17
Fecal Coliform	0.16
Nitrate	0.1
pH	0.11
Temperature	0.1
TS	0.07
Total Phosphate	0.1

Table 3. Water quality classification according to NSFWQI

Water quality	Index
Excellent	91–100
Good	71–90
Medium	51–70
Unsuitable	26–50
Very unsuitable	0–25

RESULTS AND DISCUSSION

Water quality of Mojen River during different seasons

The water quality of Mojen River during different seasons are presented in Table 4 and highlighted as follow:

- **Winter Season:** pH of water samples varied between 7.03 at Darkhaniab to 7.21 at Pole. Total Solids (TS) varied between 1490 mg/l at Sigareh to 1430 mg/l at Chenarbon. Dissolved Oxygen varied between 6 mg/l to 6.4 mg/l. Likewise BOD values varied between 4.2 mg/l at Darkhaniab to 4.7 mg/l in Serah. Nitrate varied between 16.2 mg/l at Serah to 18.9 mg/l at Sigareh.
- **Spring Season:** pH of water samples varied between 7.14 at Sigareh to 7.3 at Chenarbon. Total Solids (TS) varied between 1340 mg/l at Serah to 1360 mg/l at Darkhaniab. Dissolved Oxygen varied between 6.1 mg/l to 6.3 mg/l. BOD values varied between 4.3 mg/l to 4.4 mg/l. Nitrate varied between 15.8 mg/l at Chenarbon to 17.2 mg/l at Sigareh.
- **Autumn Season:** pH of water samples varied between 7.01 at Drakhaniab to 7.31 at Serah. Total Solids (TS) varied between 1290 mg/l at Drakhaniab to 1320 mg/l at Pole. Dissolved Oxygen varied between 6.1 mg/l to 6.4 mg/l. BOD values varied between 4.2 mg/l to 4.6 mg/l. Nitrate varied between 15.2 mg/l at Drakhaniab to 17.8 mg/l at Sigareh.

Low concentration of BOD was recorded during winter due to a huge volume of fresh water that diluted the organic matter resulting in the decrease in the BOD values.

Value of National Sanitation Foundation Water Quality Index (NSF WQI)

NSF WQI of Mojen River is depicted in Table 5. The classification criteria standards based on NSF WQI are given in Table 6. The following observations were made based on the National Sanitation Foundation Water Quality Index of Mojen River at up, mid and downstream.

The obtained values of NSFWQI at stations (Table 5) shows that the water quality at all stations are Medium.

Figure 2 shows that downstream of Mojen River in Pole Sampling point had a much worse situation than other points, due to discharge of numerous factories swages in to the river. However, Mojen River condition is relatively more appropriate than other rivers due to less villages and residential area around the river. Among all the sampling points, the water quality at Drakhaniab (Upstream) is the less polluted as the NSF WQI is the highest.

Table 4. Water quality during different seasons – Mojen River

Location	Season	Turbidity [NTU]	BOD [mg/l]	DO [mg/l]	Fecal Coliform [MPN/100nl]	Nitrate [mg/l]	pH	Temperature [°C]	TS [mg/l]	Total Phosphate [mg/l]
Drakhaniab (Upstream)	Winter	5	4.2	6.4	2380	16.8	7.1	17.3	1450	0.22
	Spring	5	4.4	6.2	2350	15.9	7.21	18.9	1360	0.22
	Autumn	6	4.6	6.1	2340	15.1	7.01	19.6	1290	0.21
Chenarbon (Upstream)	Winter	5	4.4	6.2	2350	16.3	7.03	17.2	1430	0.22
	Spring	6	4.6	6.1	2380	15.8	7.3	19.3	1350	0.21
	Autumn	6	4.3	6.3	2350	15.7	7.11	19.5	1300	0.21
Sigareh (Midstream)	Winter	5	4.4	6.2	2360	18.9	7.12	17.2	1490	0.2
	Spring	5	4.4	6.2	2360	17.2	7.14	19.1	1340	0.2
	Autumn	5	4.2	6.4	2370	17.8	7.16	19.2	1305	0.2
Pole (Midstream)	Winter	6	4.3	6.3	2390	16.8	7.21	17.1	1470	0.21
	Spring	5	4.3	6.3	2390	16.9	7.19	19	1360	0.21
	Autumn	4	4.4	6.2	2360	17.2	7.31	19.2	1320	0.21
Simaneh (Downstream)	Winter	5	4.6	6.1	2350	17.5	7.09	17.3	1460	0.22
	Spring	6	4.4	6.2	2340	17.2	7.24	19.1	1350	0.22
	Autumn	4	4.6	6.1	2350	17.6	7.14	19.3	1307	0.22
Serah (Downstream)	Winter	5	4.7	6	2370	16.2	7.11	17.1	1440	0.23
	Spring	4	4.4	6.2	2380	16.5	7.22	19.2	1340	0.21
	Autumn	4	4.6	6.1	2370	17.5	7.31	19.3	1300	0.21

Table 5. NSFWQI values in Sampling points-Mojen River

Station No.	Sampling Point	Turbidity [NTU]	BOD [mg/l]	DO [mg/l]	Fecal Coliform [MPN/100nl]	Nitrate [mg/l]	pH	Temperature [°C]	TS [mg/l]	Total Phosphate [mg/l]	NSFWQI	Description	Class
1	Drakhaniab	5.3	4.4	6.23	2356	15.93	7.11	18.6	1366	0.22	62	Medium	C
2	Chenarbon	5.6	4.4	6.23	2360	15.93	7.15	18.67	1360	0.21	61	Medium	C
3	Sigareh	5	4.3	6.23	2363	17.97	7.14	18.5	1378	0.2	60	Medium	C
4	Pole	5	4.3	6.23	2380	16.97	7.24	18.43	1383	0.21	52	Medium	C
5	Simaneh	5	4.5	6.13	2346	17.41	7.15	18.57	1372	0.22	57	Medium	C
6	Serah	4.3	4.5	6.1	2373	16.73	7.22	18.53	1360	0.21	56	Medium	C

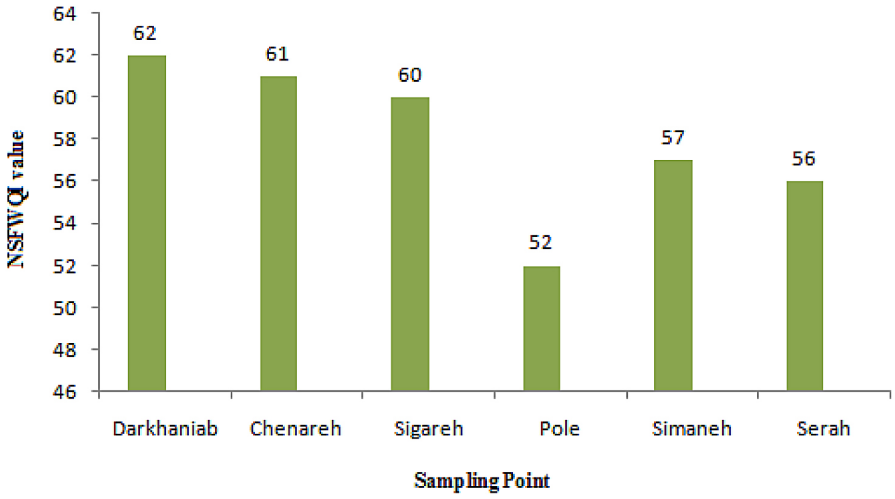

Figure 2. NSFWQI values in different stations- Mojen River

Table 6. Classification criteria standards based on NSF-WQI

NSFWQI	Descriptor	Category
91–100	Excellent	A
71–90	Good	B
51–70	Medium	C
26–50	Bad	D
0–25	Very Bad	E

Damo and Icka in 2012 studied the water quality of drinking water in the city of pogradec, Albania and the average value of NSFWQI was obtained equals to 87.81, which is placed at good region. The good quality can be attributed to the measured turbidity that exceeds the objective and to its large excursion. It reflects the intervention between natural effects and those of anthropogenic activities [17].

Mukherjee and Dora in 2012 studied water quality of Damodar River in Jharkhand and the average value of NSFWQI was obtained equals to 35, which is placed at Unsuitable region. The study shows that the river water is not potable at maximum sampling stations and are highly fecal contaminated. According to the desirable limit, maximum locations are also not even suitable for bathing [18].

CONCLUSION

We have studied the National Sanitation Foundation Water Quality Index of various sampling points of Mojen River i.e. Darkhaniab, Chenarbon, Sigareh, Pole, Simaneh and Serah in different seasons were located on the level of Medium conditions. According to NSFWQI, the best condition was related to the Darkhaniab station and the worst condition was related to the Pole station due to discharge of numerous factories swages in to the river. The obtained results showed that qualitative condition of Mojen River is medium and inappropriate management measures such as population load and excess urban activity in the basin of this river, industrial activities, excessive consumption of chemical fertilizers and pesticides, discharge of rural, urban and industrial wastewater and also solid wastes into the river which have a continuous increasing trend are the main source of river pollution.

So, human factor is the main cause of river pollution. Besides human factors, natural factors such as low rainfall, water consumption for agricultural and industrial purposes, development of agricultural lands at the expense of natural lands wastefulness and finally, all increased the physical and chemical pollution of the river and leads to natural disruption of its biological and bioavailability capacity.

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