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Limnological and pollution study of Shahdadroud River, Kerman province

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Abstract

Shahdadroud River is one of the most important rivers in Kerman province that during previous years has been threatened by drought and anthropogenic pollution. This river supplies some parts of drinking water of Kerman city and some vicinity villages. The main objective of the present study is consideration of pollution situation of the river; for this purpose, limnological and biological studies of the river were carried out seasonally in 2007. Four sampling stations including Vameghabad (station 1), Bamoghavemat (station 2), Sharifabad (station 3) and Mehrechenar (station 4) were determined based on limnological standard method along the river; afterwards sampling of invertebrates (biological index) and water quality (BOD) were performed seasonally during study period. The results showed that station 1 is free of pollution while the station 2 is the most polluted region at the river; because the station 1 has no pollutant resource but the station 2 receives wastewater of rainbow trout fish culture center directly. Based on findings of biomonitoring and water BOD measurement, Shahdadroud River has relatively high-polluted situation and is classified in α-mezosaprobe class.

Keywords: Kerman; Shahdadroud River; Limnology; BOD; Pollution

1. Introduction

River is one of the most important aquatic ecosystems in arid and semi-arid regions of southeastern Iran. Shahdadroud River is located in northeastern Kerman city and like other central Iran basin rivers originates from from highlands and then is terminated in central plateau. The river is worthwhile from view point of biodiversity and drinking water in arid and semi-arid regions. Shahdadroud River during previous years has been threatened by drought and anthropogenic pollution. Seasonal variations of precipitation, surface runoff, interflow, groundwater flow and pumped outflows have strong effects on river discharge and subsequently, on the concentration of pollutants (Vega *et al.,* 1998). Biological monitoring methods are playing an increasingly important role in river quality monitoring, mainly due to the fact that the biota are continuous witnesses of the river's state of health and are collectively sensitive to the whole range of potential pollutants (Grobvi *et al.,* 1997). Aquatic invertebrates were found to be effective estimators of overall and integrated water quality and stream health conditions due to their great diversity, sensitivity to environmental impact, and their omnipresence. Biological monitoring is a useful means of detecting anthropogenic impacts to the aquatic community.

Water pollution and shortage of clean water reservoirs is one of the most urgent problems of recent decades our times. Amounts of water used in industrial processes and households'

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demands are enormous and so are amounts of wastes and number of various contaminations. One of the most common contaminations is the organic pollutants, which can originate from different sources (Zawala *et al.,* 2007). The assessments of water quality contaminations require monitoring of a wide range of physical, chemical and biological parameters. The usual situation is the measurement of multiple parameters, taken at different monitoring times, and from many monitoring stations (Chapman, 1992). Biochemical oxygen demand (BOD) is the amount of dissolved oxygen that is consumed by aerobic, heterogeneous populations of micro-organisms to oxidize or degrade the carbonaceous and nitrogenous components of biodegradable organics in water. It is one of the key variables in waterquality assessment (Revelli and Ridolfi, 2004). One of the most important anthropogenic impacts on the environment is the disposal of wastes that originate from human activities. Among liquid wastes, wastewaters contaminated by biodegradable pollutants constitute a common by-product of both civil settlements and industrial facilities. This class of substances is known as biochemical oxygen demand (BOD) (Boano *et al.,* 2005). BOD is employed as a gross measure of the oxygen demanding potential of the effluent. Assimilative capacity varies in accordance with variations in hydrodynamic conditions and other ecological processes (Babu *et al.,* 2005). Degradation of organic matter by heterotrophic bacteria is one of the major processes controlling the oxygen level of aquatic ecosystems and thus their quality. In most aquatic ecosystems, organic matter has a mainly autochthonous origin but, for rivers flowing through urbanized areas, wastewater effluents can be the major source of organic matter (Servais *et al.,* 1995). In the present study, Shahdadroud River condition was evaluated from viewpoint of pollution; because some parts of drinking water of Kerman city and vicinity villages are supplied from this river. In the first stage of the study, four sampling stations were established based on limnological standard method (Hynes, 1970); then sampling of invertebrates and water quality (BOD) were performed seasonally during the study period.

2. Materials and methods

2.1. Sampling stations

Shahdadroud River located in 25 km northeastern of Kerman city. At the present study, totally four stations, namely Vameghabad (station 1), Bamoghavemat (station 2), Sharifabad (station 3) and Mehrchenar (station 4) were selected on the river under the river quality-monitoring network. The sampling network was designed to cover a wide range of determinants at key sites, which reasonably represent the water quality of the river system accounting for tributary and inputs from wastewater drains that have impact on downstream water quality.

Table 1. Location and characteristics point of sampling stations

station	Elevation (m)	Characteristics of the station	position
Vameghabad	2253	the opposite of installations of Kerman water institute	N 30° 31′ 28″ E 57° 14′ 41″
Bamoghavemat	2032	rainbow trout fish culture center downstream	N 30° 30′ 33″ E 57° 16′ 15″
Sharifabad	1639	Mohammadshah and Keliseki tributaries downstream	N 30° 27′ 09″ E 57° 21′ 42″
Mehrchenar	1065	Darsakhti tributary downstream	N 30° 14′ 23″ E 57° 36′ 41″

2.2. Invertebrate and water sampling

Invertebrate and water samples (BOD) were collected each season at three points (1/4, 1/2 and 3/4) across the river width at all the four stations with a view to monitor changes caused by the seasonal limnological cycle during the study period (November 2006 until September 2007). Invertebrate sampling was accomplished by surber or foot square-foot sampler and BOD of the water samples were determined by winkler method (Chapman, 1992).

3.2. Biologic index (Z) estimation

To determine river water quality, estimating the biological index is requirement. Biological index is calculated by Baur formula (Baur, 1980) and Wegl invertebrate benthos table (Wegl, 1983) as below:

$$Z = \frac{\sum o + 2\sum \beta + 3\sum \alpha + 4\sum p}{\sum h}$$

Z= Biological Index

∑o= Number of invertebrates related to oligosaprobe region
∑β= Number of invertebrates related to β-mezosaprobe region
∑α= Number of invertebrates related to α-mezosaprobe region
∑p= Number of invertebrates related to polysaprobe region
∑h= Total number of invertebrate samples

Table 2. Biological index and river saprobic condition (Ahmadi and Nafisi, 2001)

Biological index (Z)	Water quality	Water region	Saprobic condition
1-1.5	Good	I	Oligosaprobe
1.5-2.5	Moderate	II	β-mezosaprobe
2.5-3.5	Relatively weak	III	α-mezosaprobe
3.5-4	Weak	IV	polysaprobe

4.2. Statistical Analysis

The data were normalized by Shapiro-Wilk test and then were analyzed statistically. Data were subjected to multiple-way ANOVA; significant differences between the means were compared with the Duncan's test, and statistical significance was tested at a 0.05 probability level using SPSS software.

3. Results

1.3. Biological index

The sampled aquatic invertebratess were identified and based on their tolerance index and biological index formula (Baur, 1980) at each station were calculated seasonally (Table 3). Comparison of biological index among sampling stations during study period are showed in Figure 1.

Table 3. Biological index at different stations during study period

Sampling station	Spring	Summer	Autumn	Winter
1	1.3 ± 0.07^{a}	1.38 ± 0.14^{a}	1.46 ± 0.11^{a}	1.33 ± 0.14^{a}
2	2.52 ± 0.13^{b}	2.81 ± 0.18^{c}	2.91 ± 0.25^{c}	2.62 ± 0.32^{b}
3	2.31 ± 0.26^{b}	2.51 ± 0.24^{b}	2.35 ± 0.27^{b}	2.48 ± 0.24^{b}
4	2.56 ± 0.21^{b}	3.04 ± 0.19^{c}	3.27 ± 0.31^{c}	2.75 ± 0.29^{b}

Values with the same superscript letters in a column are not significantly different at the 0.05 level

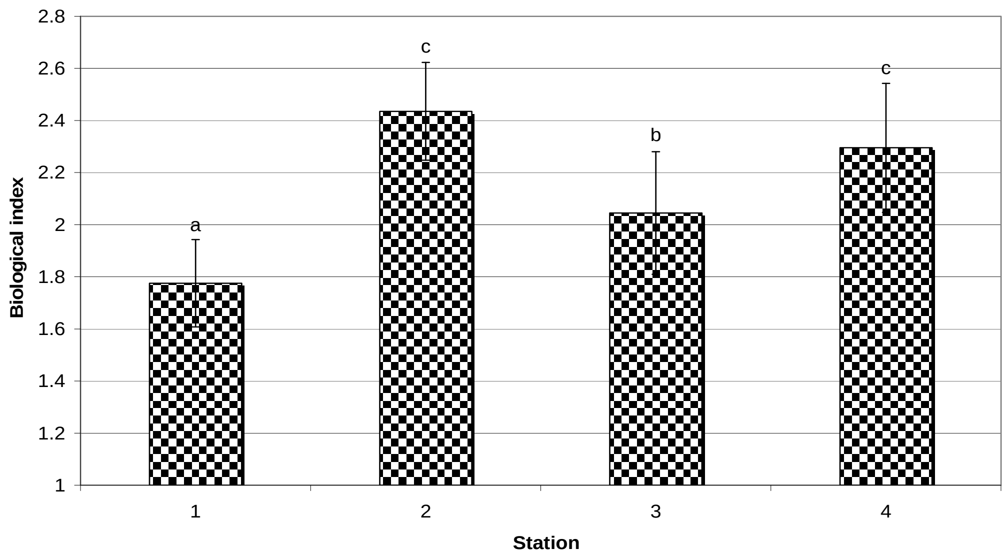

Fig. 1. Comparison of average biological index of four seasons among studied sampling stations

2.3. BOD

The results of BOD measurement are given in Table 4. BOD value in the first station showed significant difference (P<0.05) and its value was the least that indicate lower pollution compared to other stations. The second station sampling in spring and summer showed significant differences (P<0.05) and its value was higher than other stations that related to rainbow trout fish center wastewater mainly.

Table 4. Water BOD at different stations during study period

Sampling station	Spring	Summer	Autumn	Winter
1	1.59±1.11 [a]	2.38±0.93 [a]	3.27±0.76 [a]	3.63±1.05 [a]
2	10.49±0.88 [c]	13.23±1.16 [c]	14.18±1.28 [b]	15.32±1.22 [b]
3	7.54±0.89 [b]	10.41±0.79 [bc]	11.74±1.62 [b]	13.44±1.51 [b]
4	8.17±0.95 [bc]	9.04±1.19 [b]	12.07±1.57 [b]	12.19±1.29 [b]

Values with the same superscript letters in a column are not significantly different at the 0.05 level

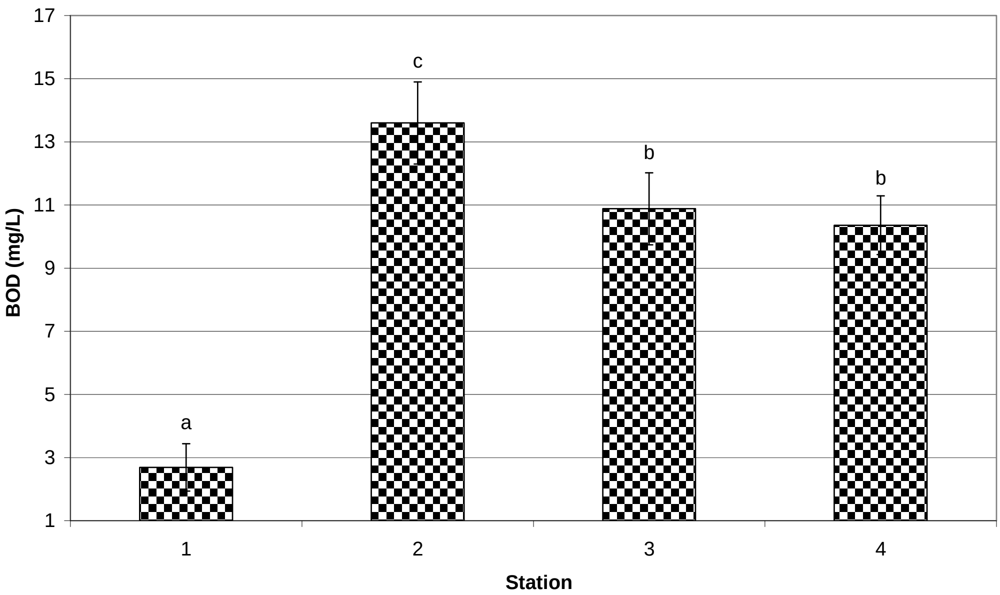

Fig. 2. Comparison of average BOD for four seasons among studied sampling stations

4. Discussion

At the present study, water quality and biological index in four sampling stations at Shahdadroud River were considered seasonally. Based on baur formula (Baur, 1980) and Wegl invertebrate benthos table (Wegl, 1983) to calculate biological index. Indices are useful tools to communicate with managers because they reduce complex scientific data, integrate different types of information, and produce results that can be easily interpreted in the perspective of water quality management (Wilson and Jeffrey, 1994). Aquatic invertebrates were found to be effective estimators of overall and integrated water quality and stream health conditions due to their great diversity, sensitivity to environmental impact, and their omnipresence. The use of the benthic invertebrate fauna as an indicator for a qualitative classification of freshwater systems has increased in many regions of the world within the last years (Roldan, 2003). The value of biological index in spring season showed significant difference ($P<0.05$) in first station compared to other stations (Table 3). This matter indicates high quality water at the station 1 while other stations are affected by anthropogenic, agriculture and aquaculture activities. In summer and autumn seasons, the number of biological index at stations 2 and 4 showed significant increasing during the study period (Table 3); this matter may reflect (1) higher feeding and wastewater by fish and livestock culture centers and/or (2) decreasing the river water discharge by seasonal fluctuations. Pollution has the potential to affect the biological integrity of aquatic systems, decreases the quality of waters and may directly affect aquatic animals. The effects of anthropogenic disturbances in the receiving systems can be assessed by measuring changes in community structural parameters including biodiversity indicators, biotic indices and community structure. In winter season like spring, with increasing precipitation, the river pollution and the biological index number at station 1 showed significant differences ($P<0.05$) compared to other stations (Table 3).

Comparison of biological index among sampling stations annually showed significant difference in station 1 (Figure 1) and in point of saprobic and pollution view related to oligosaprobe class because the station 1 had been selected upstream the river where there were no any pollution resources. The BOD data was corresponding and showed the least value at this station (Figure 2). There is an incompatibility between stations 3 and 4 in BOD and biological index value (Figure 1, 2) and station 4 in spite of higher biological index value compared to station 3 has lower BOD value. This matter is related to self-purification opportunity in station 4; since distance of pollutant point to sampling station in station 4 is higher than station 3. Pollutant from agricultural and farming activities, untreated urban sewage and industrial effluents driven into the river by wastewaters or surface runoff can be the cause of severe pollution. Threshold values for pollutant load in wastewater, established independently of the river flow rate, are not protected from pollution since the mechanisms that determine water quality are mixing, transport and species reactions occurring in the receiving water body (Campolo *et al.,* 2001).

Station 2 which is affected by rainbow trout culture center is placed by β-mezosaprobe class; this matter can relate to (1) feeding and over feeding the fish culture center (2) fish fecal (3) carcass of dead fish (4) used drugs in the fish culture. Station 3 not only has exposed to agriculture, another fish culture and semi-industrial livestock farm wastewaters but also receive domestic and urban contaminant. According the results, this station was assessed as the most pollution region along the Shahdadroud River that indicates the presence of biodegradable organic matter in the water column. BOD measurements confirmed that results at 2 and 3 stations (Figure 2). Contamination generated from upstream development, agriculture wastewater and human activity introduces a significant amount of nutrients and organic into rivers, thus, accelerates the hypoxia or eutrophication process, spoils the public water resources, and caused high BOD. Station 4, however has located downstream of station 3 but showed lower pollution than this station, because the river with self-purification phenomenon decrease the receive pollution. This station based on saprobe and pollution view is placed in α-mezosaprobe class. In the river biomonitoring all observed invertebrate at this station nearly connected to the third pollution region, One of the major advantages of biomonitoring with benthic invertebrates is the possibility to detect changes in water quality that occur at the time of sampling as well as changes that have occurred within a longer period before sampling, due to the relatively sedentary life style and long life span of these organisms (Rosenberg and Resh, 1996; Schwoerbel, 1999).

5. Conclusion

Based on biomonitoring and water BOD measurement findings, Shahdadroud River has relatively high-polluted situation and is classified in α-mezosaprobe class. Station 1 is free of pollution while the station 2 is the most polluted region at the river; because the station 1 has no pollutant resource but the station 2 receives wastewater of rainbow trout fish culture center directly. Stations 3 and 4 have moderate pollution situation; because these stations in spite of receiving pollutants have self-purification opportunity relatively. Aquatic insect species and their frequency that mainly relate to pollution regions two and three, indicate to weak biological condition at Shahdadroud River. Based on EPA standard water quality in station 1 is suitable only for drinking.

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