

Assessment of River Ecological Quality Using B-IBI (Dez River, Southwestern of Iran)

Maryam Mohammadi Rouzbahani, Nasrin Roghani zadehgan, and Amir Harirforoush

Abstract—The aim of this study is to develop a benthic index of biotic integrity (B-IBI) to help understand how the increasing anthropogenic pressure may impact the permanent Dez River in Iran. For this propose, 5 sampling stations with 4 replicates has been selected from January 2012 to June 2013. Also physiochemical parameters of water, grain size analysis and percentage total organic matter (TOM) of sediment was determined. We selected ten metrics for the final IBI. 19 species from 12 families of macrobenthose have been identified. The highest abundance was belong to Oligochaetes with 80% and the lowest was belong to Gastropoda with 14.5%. The results of B-IBI showed that most sites were in fairly poor condition. These results suggest that the B-IBI may be a suitable method for assessing Dez river conditions and other rivers with same weathering and ecological conditions.

Index Terms—River pollution, benthic macro-invertebrates, biomonitoring, Dez River.

I. INTRODUCTION

Since aquatic ecosystems such as streams and rivers are among the most endangered ecosystems worldwide, there are urgent demands for comprehensive methodological approaches to evaluate the actual state of these ecosystems and to monitor their rate of change [1], [2]. Part of the decline in water resources stems from insufficient consideration of their biological structure and function [2].

Some factors have been reported which are linked to river degradation. Physical and chemical factors may be related to biological changes [3]. Water quality may only partially reflect environmental impact [1]. Physical, chemical and bacteriological measurements commonly form the basis of monitoring, because they provide complete spectrum of information for proper water management [4]. However, in running waters, where changes in hydrology are rapid and difficult to estimate, they cannot reflect the integration of numerous environment factors and long-term sustainability of river ecosystems for their instantaneous nature. Therefore biomonitoring has been proven to be necessary supplementary to those traditional monitoring techniques [5]. Biological indicators are especially useful in a comprehensive water quality program as they reflect the habitat conditions in the aquatic system as well as water quality conditions over a longer term than noncontinuous water quality sampling. Several types of organisms can be used in biological monitoring such as fish [1], invertebrates, and periphyton, however, the Benthic Index of Biotic

Integrity (B-IBI) uses benthic invertebrates (or invertebrates found in stream substrate) and has been successfully and cost-effectively incorporated into many water quality monitoring programs worldwide [1], [6].

The B-IBI is based on a series of structural and functional metrics of benthic macroinvertebrate assemblages, and thus helps quantify the impact of environmental deterioration [2].

The purpose of this research is to develop a benthic IBI (B-IBI) for the Dez River in southwestern Iran to reflect anthropogenic stresses on river.

II. MATERIALS AND METHODS

The present study was conducted on the Dez River, in Khuzestan province, southwestern Iran. This river is one of the most important rivers in Iran. Data were obtained from 5 stations from January 2012 to June 2013 in the middle of each season (Fig. 1).

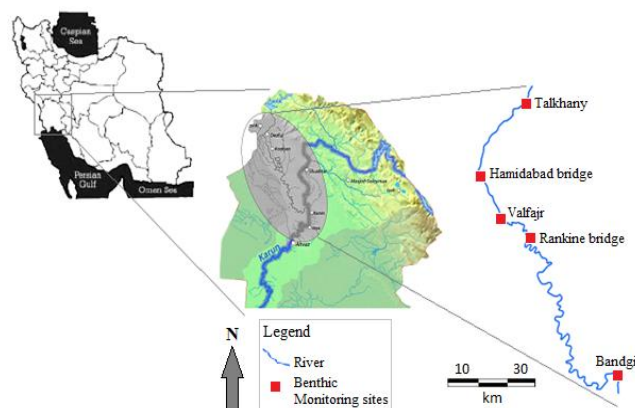


Fig. 1. The location of stations in Dez River (2012-2013).

Physicochemical parameters of water such as salinity (PSU), temperature ($^{\circ}\text{C}$), dissolved oxygen (mg/l), pH (units) and conductivity (μS) were determined in seasons using Hydrolab multimeter (HORIBA, U10). Samples were collected using a Vanveen grab (0.025 m^2) taking four replicates at each station. 3 replicates for macrobenthose analysis and 1 sample with three replicates for grain size and total organic matter of the sediment were considered. In stations that grain size of sediments was high, used Surber net for sampling Macrobenthose communities. Macrobenthose samples were sieved on a board with a 0.5 mm mesh size, preserved in 5% formalin solution in sea water and then transferred to the laboratory. The samples were preserved in 99% ethanol and then transferred into 1 g/l of Rose Bengal solution stain for identification [7]. Benthic species were sorted under a dissecting microscope using $16\times$ magnification and all macroinvertebrates were identified to the lowest possible taxonomic level, often to family level, by use of systematic and classification keys.

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Previous studies have shown that this level of taxonomic resolution is cost-effective and is sufficient for detecting effects associated with a variety of anthropogenic disturbances. In order to determine distribution of sediment particle size, the first part of each sample was dried at 70 °C for 48 h and sieved through a nested series of sieves. The other part of each sample was first dried at 70 °C for 48 h and then combusted at 550 °C for 60 min to determine the total organic matter content through weight loss [8]. Then benthic index include B-IBI has been determined using 10 criteria that was needed. The B-IBI is based on a series of structural and functional metrics of benthic macroinvertebrate assemblages. Structural B-IBI components include species richness, habitat guilds, trophic structure, organismal abundance and biodiversity. Functional components consist of feeding and trophic categories, environmental tolerance, and individual stress and condition groupings. The index component of the B-IBI description indicates that several types of data are synthesized into a single number that depicts overall biological condition. The B-IBI is a multi-metric index in

which several metrics of the invertebrate community are calculated, and given a score, and then those scores are combined to give the index value. Metrics such as the number of pollution tolerant taxa, the total number of taxa, and population attributes such as the number of long-lived taxa or predator taxa are used to assess the health of the community. These metrics, once combined into a single index score, indicate the relative health of the system and are correlated to ratings and descriptions. The ratings used for this analysis consist of the following: Healthy, Compromised, Impaired, Highly Impaired, and Critically Impaired [5]. The B-IBI is both habitat and season dependent. Therefore data must be selected for time of year and pre-classified according to the habitat type from which the samples were collected. The biological metrics for stream invertebrates, response to human disturbance, and scoring rules used to integrate into the B-IBI presented in Table I. Also B-IBI classifications of stream conditions are shown in Table II. Data analyses were made using the Statistical Package for the Social Sciences (SPSS) version 13.

TABLE I: BIOLOGICAL METRICS FOR STREAM INVERTEBRATES, RESPONSE TO HUMAN DISTURBANCE, AND SCORING RULES USED TO INTEGRATE INTO THE B-IBI

Metrics: Taxa richness and composition	Response	Scoring Criteria		
		1	3	5
Total number of taxa ¹	Decrease	[0, 14)	[14, 28]	> 28
Number of Ephemeroptera taxa ¹	Decrease	[0, 3.5)	[3.5, 7]	> 7
Number of Plecoptera taxa ¹	Decrease	[0, 2.7)	[2.7, 5.3]	> 5.3
Number of Trichoptera taxa ¹	Decrease	[0, 2.7)	[2.7, 5.3]	> 5.3
Number of long-lived taxa ²	Decrease	[0, 4)	[4, 8]	> 8
Tolerance				
Number of intolerant taxa ²	Decrease	[0, 2)	[2, 4]	> 4
% of individuals in tolerant taxa ¹	Increase	> 44	[44, 27]	27 >
Feeding ecology				
% of predator individuals ¹	Decrease	[0, 4.5)	[4.5, 9]	> 9
Number of clinger taxa ¹	Decrease	[0, 8)	[8, 16]	> 16
Population attributes				
% dominance (3 taxa) ³	Increase	≥ 75	(75, 55]	55 >

1 mean of three replicates, 2 cumulative of three replicates, 3 three of the most abundant taxa

TABLE II: B-IBI CLASSIFICATIONS OF STREAM CONDITION, DESCRIPTION AND RANGE OF VALUES

B-IBI values	Site condition	Description
50-46	Healthy	Ecologically intact, supporting the most sensitive life-forms.
44-36	Compromised	Showing signs of ecological degradation. Impacts expected to one or more salmon life-stages.
34-28	Impaired	Healthy ecosystem functions demonstrably impaired. Cannot support self-sustaining salmon populations.
26-18	Highly impaired	Highly adverse to salmon and various other life-forms.
16-10	Critically impaired	Unable to support a large proportion of once-native life-forms.

TABLE III: DISTRIBUTION OF IDENTIFIED MACROBENTHOS SPECIES IN DEZ RIVER (N/M²)

Species		Tubifex tubifex	Specaria josinae	sp. Erpobdella	Chironomus riparius	Hermetia illucens	Corbicula fluminea
Family		Tubificidae	Naididae	Erpobdellidae	Chironomidae	Stratiomyidae	Corbiculidae
Class		Oligochaeta		Hirudinea	Insecta		Bivalvia
Summer(2013)	Station	1	2717.6±5427	919.6±7979	-	52.9±103	-
		2	-	485.7±5256	-	312.2±396	118±118
		3	-	1891±3755	-	242±396	132±132
		4	-	-	-	-	-

		5	14.7±161	-	67.2±176	-	-	-
Winter(2012)	Station	1	1652±9739	704.6±16133	-	77.6±117	-	-
		2	-	4429±9621	-	586.7±675	-	264±264
		3	-	4956±9093	-	854.7±1144	29±29	410.7±763
		4	-	-	-	-	-	-
		5	187.3±337	-	163.3±601	-	-	-

Tryonia clathrata	Tryonia exigua	Bithynia tentaculata	Melanopsis frustulum	Melanopsis attenuata	Melanopsis buccinoidea	Physella acuta	Nerita funiculate	Theodoxus danubialis	Neritodryas dubia	Theodoxus fluviatilis	Pettancylus nipponicus
Hydrobiidae		Bithyniidae	Melanopsidae			Physidae	Neritidae				Ferrissidae
Gastropoda											
-	-	-	-	-	-	-	-	-	-	-	-
-	-	101.6±176	140±513	103±205	-	94±117	103±249	76±132	-	-	-
44 ±44	-	191 ±191	177.8 ±484	64 ±191	132 ±132	-	278.6 ±645	114.6 ±205	101.6 ±176	-	89.2 ±161
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	110.7 ±308	191.8 ±352	116 ±792	91.6 ±132	470 ±470	338 ±499	-	411 ±411	-	29 ±29
29 ±29	29 ±29	152 ±396	255.7 ±411	383.6 ±1012	205 ±205	59 ±59	487 ±895	96.2 ±601	471 ±1203	165.3 ±293	331 ±557
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-

III. RESULTS AND DISCUSSION

In this study we collected and identified 18 macroinvertebrate taxa. Several taxa were ubiquitous among moderate- to minimum-influence sites, especially genera in the families Naididae and Chironomidae. Chironomids were the only taxon at sites with severe point-source pollution. The identified macrobenthos species in Dez River are shown in Table III.

Abundance percentage of Macrobenthos classes showed that 80% belong to Oligochaeta (Fig. 2).

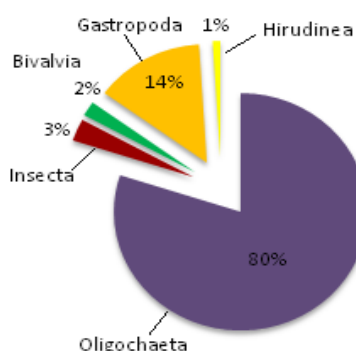


Fig. 2. Abundance Percentage of Macrobenthos classes in Dez River (2012-2013).

The measured results of physico-chemical parameters of water showed that there were significant differences between physico-chemical parameters of water in the stations of seasons ($P<0.05$). The results of physico-chemical parameters during two seasons showed little fluctuations ($P>0.05$). The minimum amount of temperature belongs to station1 in winter (14.47 ± 0.47) and maximum amount belong to station3 in summer (31.3 ± 0.75). Along

two seasons, highest amount of turbidity (69.17 ± 9.17) and EC (2002.5 ± 12.5) belong to station5.

The results of the grain size analysis are shown in Fig. 4. The results showed that more than 68% of the grain size of the sediment in station3 were >0.125 , and in other stations more than 65% of sediments were <0.063 mm.

TABLE IV: SEASONAL VALUES OF B-IBI IN DEZ RIVER (2012-2013)

Sites	B-IBI			Site Condition
	Winter	Summer	Entire period	
1	12	12	12	Critically impaired
2	18	18	18	Highly impaired
3	22	18	20	Highly impaired
4	Azoic	Azoic	Azoic	Azoic
5	16	16	16	Critically impaired

The results of the total organic matter of sediment analysis are shown in Fig. 5. The highest mean of percentage TOM was obtained in winter (5.04%) and the lowest obtained in summer (4.48%). The highest amount of TOM in two seasons belongs to station4 with the mean 9.35% and the minimum belong to station3 with the mean 2.01%. According to statistical analysis, there were significant differences between percentage TOM of sediment in seasons and stations ($P<0.05$).

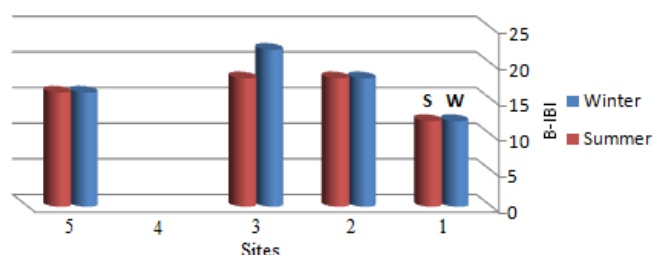


Fig. 3. Seasonal values of B-IBI in Dez River (2012-2013).

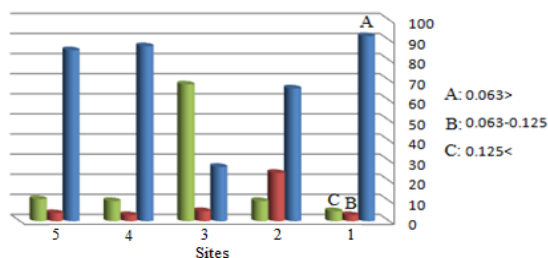


Fig. 4. The percent of sediment grain size in Dez River (2012-2013).

The B-IBI results showed that stations classified as highly impaired and critically impaired (Table IV). Also one of the stations (station4) classified as Azotic because of there wasn't any macroinvertebrate species in this station. It shows that there is very high pollution in this station (Fig. 3).

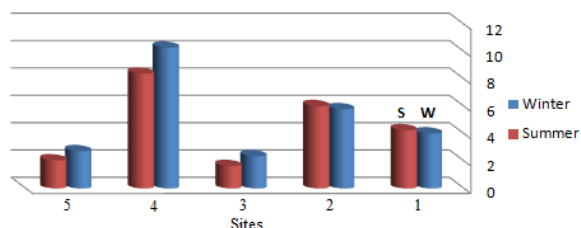


Fig. 5. Total organic matter percent of sediments in Dez River (2012-2013).

IV. CONCLUSION

On the basis of B-IBI results, study area classified as highly impaired and critically impaired. Also one of the stations (station4) classified as Azotic because of there wasn't any macroinvertebrate species in this station. It shows that very high pollution in this station. It is similar to Morley *et al.* study at 1999 [9]. Physiochemical parameters of water, total organic matters and grain size of sediments are important factors that effect on diversity and frequency of macrobenthos communities. This is proved by Boyle and Fraleigh, 2003. The presence and absence of macrobenthos in rivers shows natural and anthropogenic effects. In this research, Oligochaeta with highest frequency belong to station1. This station has a severe pollution because of effluent of sewage effluent without any treatment. The results from polluted stations is proved by B-IBI and this is confirmed by Saunders *et al.*, 2007 [10]. Highest frequency of Oligochaeta is a good index for organic pollutions. An important point about resulting from B-IBI is that considering the sampling site conditions. Effluent of agricultural, industrial and anthropogenic pollutants to Dez River, caused to depleting sensitive groups of macrobenthos. We propose that this index will be used in other rivers for assessing ecological quality of them.

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