

Effectiveness of Macroinvertebrate-Based Biotic Indexes in Assessing Lake Water Quality in Gahar, Iran

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Abstract: One of the best practical methods to understand ecological status of a water body and determine impacts of human intervention in reducing water quality is using benthic macroinvertebrates as assessment tools for monitoring their biological integrity and health. The aim of this study is determining the water quality of Gahar Lake by using of Hilsenhoff Family Biotic index (HFBI) index and identify the society of macroinvertebrates in level of the family. This research was achieved in 2011 along 3 season sampling in four different station in the small Gahar (first station), the input of small Gahar to large Gahar (second station), the centre of great Gahar (third station) and the of output great Gahar (fourth station) was taken and it has identified for family level in the laboratory. In which they have most variety and abundance in the spring season, also they are having least variety and abundance in the autumn season and maximum density belongs to Simuliidae and Chironomidae. The result was indicated that output great Gahar station (fourth station) had the highest density and diversity to another stations. The Biological index of Gahar Lake that obtained 1.75, was achieved by using estimates of water quality based on HFBI, lake water quality was excellent and without apparent organic pollution.

Key words: Benthos • Water Quality Assessment • HFBI Index • Gahar Lake

INTRODUCTION

The use of benthic macroinvertebrate fauna as an indicator for a qualitative classification of freshwater systems has increased in many regions of the world within the last years [1, 2]. One of the major advantages of bio-monitoring with benthic macroinvertebrates 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 spans of these organisms [3, 4]. Identify and study about the quality and quantity of water sources is one of the important pillars of sustainable development. Studying about lakes and streams is very important and is effective in diagnosis of ecosystem health of lakes but can indicative the pressures of the environment around [5].

Traditional method can't indicate water quality and situations of water course completely. The use of aquatic insects and other benthic macroinvertebrates to assess the quality of rivers and streams has a long and well documented history [6, 7, 8]. The benthic macroinvertebrate populations, in addition to various chemical and biological assessment parameters, are used to characterize a river's or lake's current water quality and can chart trends within a particular water course [9]. Benthos are one most important organism that can transmit primary product detritus to high level of food chain in reside water. The benthic macroinvertebrate communities, of which the aquatic insects and especially the aquatic nymphs comprise a critical niche, are favored as a reliable and relatively low-cost indicator of the biotic health of water bodies [9]. Nowadays the use of aquatic insect fauna for determining biological indicators and

water quality has great value and the relationship between basic researches was done by Hilsenhoff [10], Bode *et al.* [9], Bode *et al.* [11], Barbour *et al.* [12] and Haur and Lamberti [13] and is the basis of studies in this field. The tolerance of aquatic insects against water pollution has been evaluated 0 to 10 by Hilsenhoff [14]. Water quality based on biological indicators obtained and changes are shown in tables [10, 14] Research by the [15, 16] on aquatic insect fauna Lake Parishan was performed. Biological indicators of lake obtained were 5.62 and the water quality of the lake was fair and significant organic pollution by using the table. Also the investigators obtained the biological index of Shapur River is 3.79 by using the aquatic insect fauna obtained in Kazeran region which indicative that the water quality of the river was very good and possible slight organic pollution [17]. The purpose of this study on Gahar Lake was to continue specialized tasks and applications about the studying of benthos and its use in determining the water quality on basis of HFBI index.

MATERIALS AND METHODS

This study was Gahar Lake is located in Oshtorankooch (Iran). There are a lot of ways to access Gahar lake. The main way of it: Small Gahar Lake then great Gahar Lake, Valley of Nigay and Banargohar, Panbehkar Mountain, Chirbanarnarimon Mountain, Talmehzar stream, you should go without car from Sarvand Village till Khoram stream, Darb Asante's Village Roshandraz mountain (car can go), Dorod City (Fig. 1).

This way is 13 km and most tourism goes this way. Another way is from Aligodarz city and is from road of Morvazin village that short but difficult [18].

Gahar Lake located on south east of Dorod City, near highest OshtoranKoh's mountain's crests. Lakes are in this mountain include: Grate Lake Gahar, small Lake Gahar, Bareh Shoran lake and Ab-barf Chal-Kabod.

This lakes has 100 hectare. Gahar Lake has 1500 m length and the average wide is 700 m.

Sampling of Benthic Invertebrates: We sampling benthic invertebrates with grab in Gahar Lake. Specimens have washed with 500 μm by using sieve. Then they were fixed in 5% formalin and transported to laboratory.

Abundance Investigates of Benthic Invertebrate: Specimens are separated with sieve 500 μm in laboratory. And it color with Rosbengal (one gram per 1 liter) for specimen enumeration. Then specimen take to large plate. We separate specimens group by using Loop with magnification 10. The most common indexes used to evaluate stream water quality are the Hilsenhoff Family Biotic Index (HFBI) and the Invertebrate Community Index (ICI). For each taxon(usually family) a tolerance value is assigned. Using the following equation:

$$HFBI = \frac{\sum(X_i \times T_i)}{n}$$

where T_i is the number of individuals in every family. X_i is the index (tolerance) value of that family.

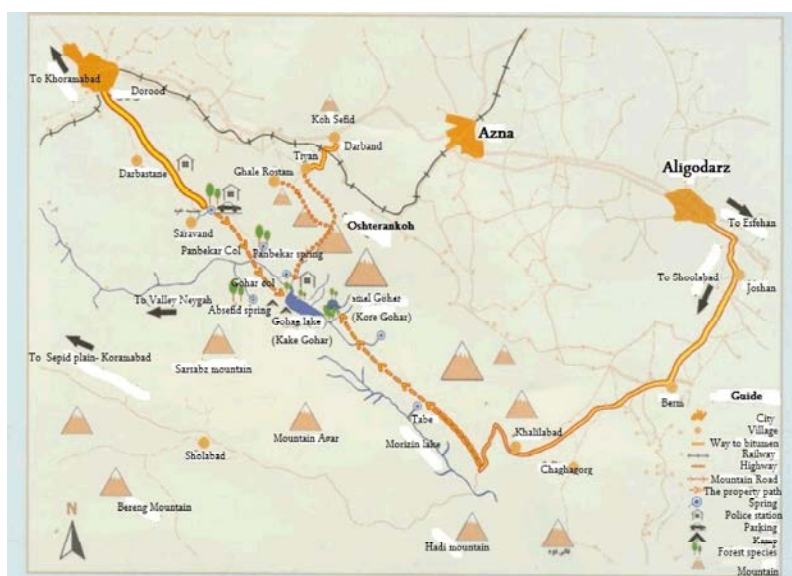


Fig. 1: Geographical location of Gahar Lake

Table 1: Characteristics of the sampling stations in Lake Gahar

ST	Location	X	Y
1	Small Gahar Lake	49° 18.770'	33° 17.624'
2	The entrance of Small Gahar Lake to the Great Gahar Lake	49°17.624'	33° 18.162'
3	Great Gahar Lake water	49°16.690'	33° 18.650'
4	The Output of Great Gahar Lake	49°16.615'	33° 18.727'

Table 2: Evaluation of water quality using biotic index [10]

Biotic Index on Family level	Water Quality	Degree of Organic Pollution
0 - 3.75	Excellent	No apparent organic pollution
3.76 - 4.25	Very good	Possible slight organic pollution
4.26 - 5	Good	Some organic pollution
5.01- 5.75	Fair	Medium possibility organic pollution
5.76 - 6.5	Fairly poor	High possibility organic pollution
6.51 - 7.25	Poor	high organic pollution
7.26 - 10	Very poor	Severe organic pollution

Table 2 is general guide for stream's water quality and it also investigate degree of population. Water quality is calculated using biotic index [10] in Gahar stream. The amount of organic pollution is calculated too in four stations in this study.

RESULTS

We investigate community of benthic Gahar Lake in this study and we found that spring season had the highest diversity and abundance with 11 families and 6 orders and 148 specimen.

Autumn season sampling had the lowest diversity with 10 families and 5 order and 260 specimens in all stations. Chironomidae and Simuliidae had the most abundance and Agrionidae and Perlidae had the lowest abundance in all season.

Most amount of density was for output of while center Grate Gahar had the lowest abundance in local investigation. Average population in benthic invertebrate had reduced term from first station to third station and then it increase in fourth station a long Gahar Lake (Table 3).

Chironomidae and Simuliidae families had the most abundance with 110 and 93 respectively in square meter, Agrionidae and Perilidae had the lowest abundance with 10 and 8 respectively in spring season. Platychemidae and Agrionidae with 9 specimens in square meter had the lowest abundance on autumn season.

Investigate Ratio of EPT/Chironomidae

Change of EPT/Chironomidae on Study Season: In this study, Ratio of EPT/Chironomidae, most in spring (0.35) and least in summer (0.12) and with an average of (0.21) were calculated (Table 7).

Table 3: Density of benthic invertebrate of different groups identified in four stations in Gahar Lake

Order	Family	Great Gahar	Input of Great Gahar	Center of Great Gahar	Output of Great Gahar	Total	Average	Percent
Ephemeroptera	Ephemeridae	10	12	6	10	38	9.5± 2.51	3.65
	Ephemerellidae	15	6	0	9	30	7.5± 6.24	2.88
Plecoptera	Peridae	7	3	0	0	10	2.5± 3.31	0.96
Hirudinae	Piscicolidae	20	7	24	33	84	21± 10.80	8.07
	Glossiphonidae	17	19	20	27	83	20.75±4.34	7.97
	Erpobdellidae	19	14	20	23	76	19± 3.74	7.29
Diptera	Simuliidae	69	43	33	64	209	52.25±17.07	20.06
	Chironomidae	90	74	40	115	319	79.75±35.41	30.61
Pulmonata	Limnaeidae	45	40	16	39	140	35± 12.93	13.43
Zygoptera	Agrionidae	10	12	0	2	24	6 ± 5.88	2.30
	Platychemidae	5	10	8	6	29	7.25 ± 2.21	2.78
Total		307	240	167	328	1042	260.5±72.75	100.00

Table 4: Density of various benthic invertebrate identified in the Lake Gahar

Order	Family	Spring	Summer	Autumn	Total	Average	Percent
Ephemeroptera	Ephemeridae	17	9	12	38	12.67±4.04	3.65
	Ephemerellidae	13	7	10	30	10±3	2.88
Plecoptera	Perlidae	10	0	0	10	3.33±5.77	0.96
Hirudinae	Piscicolidae	30	34	20	84	28±7.21	8.06
	Glossiphonidae	27	27	29	83	27.67±1.15	7.97
	Erpobdellidae	33	33	10	76	25.33±13.27	7.29
Diptera	Simuliidae	93	60	56	209	69.66±20.30	20.05
	Chironomidae	110	135	74	319	106.33±30.66	30.61
Pulmonata	Limnaeidae	65	44	31	140	46.6±17.15	13.44
Zygoptera	Agrionidae	8	7	9	24	8±1	2.31
	Platychemidae	12	8	9	29	9.67± 2.08	2.78
Total		418	364	260	1042	347.33±85.94	100

Table 5: HFBI Index change on three season on Gahar Lake

Order	Family	Spring	Summer	Autumn	Average
Ephemeroptera	Ephemeridae	1.34	0.71	0.94	2.99
	Ephemerellidae	0.53	0.23	0.33	0.99
Plecoptera	Peridae	2	0	0	2
Hirudinae	Piscicolidae	2.5	2.83	1.66	6.99
	Glossiphonidae	2.6	2.6	2.79	7.99
	Erpobdellidae	3.03	3.03	0.92	6.98
Diptera	Simuliidae	2.66	1.72	1.6	5.98
	Chironomidae	2.06	2.53	1.39	5.98
Pulmonata	Limnaeidae	2.78	1.88	1.32	5.98
Zygoptera	Agrionidae	2.66	2.33	3	7.99
	Platychemidae	1.65	1.1	1.24	3.99
Total Index		2.15	1.72	1.38	1.75

Table 6: HFBI index changes in Gahar Lake stations

Order	Family	Small Gahar	Input of Great Gahar	Center of Gahar Great	Output of Great Gahar	Average
Ephemeroptera	Ephemeridae	0.78	0.94	0.47	0.78	2.97
	Ephemerellidae	0.5	0.2	0	0.3	1
Plecoptera	Peridae	2	0	0	0	2
Hirudinae	Piscicolidae	1.66	0.58	2	2.75	3.61
	Glossiphonidae	1.63	1.83	1.92	2.6	7.98
	Erpobdellidae	2.5	1.84	2.63	3.03	9.99
Diptera	Simuliidae	1.98	1.23	0.94	1.89	5.98
	Chironomidae	1.69	1.39	0.75	2.16	5.99
Pulmonata	Limnaeidae	1.92	1.71	0.68	1.6	5.91
Zygoptera	Agrionidae	3.33	4	0.66	0	7.99
	Platychemidae	0.68	1.37	1.1	0.82	3.97
Total Index		1.87	1.69	1.05	1.19	1.74

Table 7: Change of Ratio EPT/Chironomidae during the studied period

Family	Order	Spring	Summer	Autumn	Average
Ephemeroptera		30	16	22	22.66
Plecoptera		10	0	0	3.33
Trichoptera		0	0	0	0
Chironomidae		74	110	135	106.33
EPT+Chironomidae		114	126	157	132.33
EPT/(EPT +Chironomidae)		0.35	0.12	0.16	0.21

Table 8: Average changes of ratio EPT to Chironomidae on Gahar Lake stations

Family	Order	ST 1	ST 2	ST 3	ST 4	Average
Ephemeroptera		25	18	6	19	42
Plecoptera		7	3	0	0	2.5
Trichoptera		0	0	0	0	0
Chironomidae		90	74	40	115	79.75
EPT+Chironomidae		122	95	46	134	99.25
EPT/(EPT +Chironomidae)		0.26	0.22	0.15	0.14	0.19

Ratio of EPT/Chironomidae in the Studied Station: In this study, ratio EPT to Chironomidae, most in the first station (0.26) and least (0.14) in the fourth station and average (0.19) were calculated (Table 8).

Ratio of EPT/Chironomidae: In this study, water quality Gahar Lake by Ratio of EPT/Chironomidae were most in the spring (0.35) and autumn (0.16) and the water quality was good. The least in summer (0.12), which showed no significant change in the spring and autumn. Ratio of EPT/Chironomidae increased at any time and area of the lake is a good measure of biological and ecological conditions. It because the population and distribution of the benthic invertebrate four main groups, the Order Plecoptera, Trichoptera, Ephemeroptera and family chironomidae directly affected. However macrobenthic population will heterogeneous due to environmental stress, Chironomidae's number increase significant to invertebrate sensitive to pollution (EPT). Such as it has effected on EPT ratio and cause to decrease it [19]. Peitz [20] studied in pip stone creek river said: population three order of EPT and Chironomidae increase and indicate environmental stress. This situation due to reduction orders of EPT and Chironomidae increase and indicate environmental stress. This situation due to reduction orders of EPT.

DISCUSSION

In this study aquatic insects (Larvae) are the dominant species of benthic fauna in Gahar Lake. Insects dominated throughout the sampling period, especially the families Chironomidae and Simuliidae (Diptera) in Gahar Lake. The most diversity and density belong to these groups [21]. The Gahar lake most diversity and abundance benthic invertebrate showed during of the spring and summer. Most density belong to Chironomidae and Simuliidae's families from Pulmunata order on spring and summer in Gahar lake. The Diptera order from Chironomidae family, Pulmunata order from Limnidae's family had most density in summer and winter. The result

of this study is the same as other studies that were about circle's life and distribution of one day, Springers, leech and Diptera's orders on a lot of lake in Iran and World [22, 23, 24, 25, 26]. Chironomidae and Simuliidae and Limnaeidae families show an increase in spring and summer toward autumn.

Macrobenthic diversity and density decrease from first station to the third station during the study period in Gahar Lake. Gahar Lake during the study period macrobenthic diversity and density decreased from the first station to the third station, so 307 samples from the first station changed to 240 samples in the second station, 240 samples from 11 family in the second station changed to 167 and 9 in the third station. Then it increased to 328 samples from 10 family in the fourth station. Fourth station had the most diversity and density in Gahar Lake. The dominant macrobenthic were from two orders including: Diptera and Pulmunata and they consisted from three family Chironomidae and Simuliidae and Limunidae.

Benthic invertebrate density was 167 per square meter in the third station. Which 33 belong to Simulium genus from Simuliidae's family. The result indicate that dominant benthic have low diversity in Gahar small lake to large input.

Investigate Water Quality Indexes

HFBI Index: Biological index base formula Hilsenhoff [10, 14] obtained 1.75 in Gahar Lake. Water quality of Gahar Lake was excellent and without apparent organic pollution (with follow Table 2). According to Ostovan and Nikan [15, 16] research biological index had been 5.62 and 3.79 in Parishan Lake and Shapor River (Kazeron zone) respectively. water pollution of Gahar Lake with HF biological index was less than Parishan Lake and Shapor River. The obtained biological index of Gahar Lake is 1.75 in 11 family of benthos based on variety of pollution tolerance.

HFBI index was 1.87, in the first station, 1.69 in the second station 1.05 in the third station and 1.19 in the fourth station Gahar Lake during a year. Gahar Lake had excellent level with average 1.74 (HFBI index).

Ratio of EPT/Chironomidae: Ratio abundance of Tricoptera, Plecoptera and Ephemeroptera families to abundance of Chironomidae family is one of composition of population of benthic fauna. We observe the same ratio of abundance from four major groups of these benthic on water and river with non-turbulent environment and good biological condition, but if number of Chironomidae increase to EPT sensitive groups organism due to reduce ratio of EPT/Chironomidae that indicator environmental stress [12]. Water quality of Gahar Lake evaluate by ratio EPT/Chironomidae during year.

This index was high in spring (0.35) and autumn (0.16) and the least index was for summer (0.12). The result indicate that the first station with the lowest ratio have the most environmental stress and the fourth station with the most ratio had the lowest environmental stress. If the ratio of EPT/Chironomidae is high indicate that biological and ecological condition is appropriate in every time and zone of river. Because this situation affect directly on population and distribution to the four main benthic invertebrate (orders: Onedays, Springers, hairy wings and Chironomidae family). However number of Chironomidae increase considerably to the sensitive benthic invertebrate pollution (EPT) if benthic pollution is heterogeneity due to environmental stress.

REFERENCES

1. Blocksom, K.A. and B.R. Johnson, 2009. Development of a regional macroinvertebrate index for large river bioassessment. *Ecological Indicators*, 9: 313-328.
2. Fausch, K.D., J.R. Karr and P.R. Yant, 1984. Regional application of an index of biotic integrity based on stream fish communities. *Trans. Am. Fish. Soc.*, 113: 39-55.
3. Barry P., Baldigo, B. Gregory, Lawrence, W. Robert, Bode, A. Howard, Simonin, Karen, M. Roy, J. Alexander and Smith, 2009. Impacts of acidification on macroinvertebrate communities in streams of the western Adirondack Mountains, New York, USA. *Ecological Indicators*, 9: 226-239.
4. Voelker, D.C. and D.E. Renn, 2000. Benthic invertebrates and quality of streambed sediments in the White River and selected tributaries in and near Indianapolis, Indiana. *USGS Science for a Changing World*, pp: 55.
5. Sioli, H., 1975. *Tropical Rivers as Expressions of Their Terrestrial Environment*, Trend In terrestrial and Aquatic Research, Springer-Varleg New York, pp: 275-278.
6. Davis, W.S. and T.P. Simon. 1995. *Biological assessment and criteria: Tools for water resource planning and decision making*; Chapter 8—Development and application of biological impairment criteria for rivers and streams in New York State, pp: 97-107.
7. Thomas, L.P., D.G. Peitz and D.M. Carlisle, 2002. *Macroinvertebrate monitoring as an indicator of water quality: Status report for Wilson's Creek and Skeggs Branch, Wilson's Creek National Battlefield, 1988-2001*.
8. Zimmerman, M.C., 1993. The use of the biotic index as an indication of water quality. *Tested Studies for Laboratory Teaching*, 5: 85-98.
9. Bode, R.W., M.A. Novak, L.E. Abele, D.L. Heitzman and A.J. Smith, 2002. *Quality Assurance Work Plan for Biological Stream Monitoring in New York State*. NYS Department of Environmental Conservation, Albany, NY., pp: 115.
10. Hilsenhoff, W.L., 1988. Rapid field assessment of organic pollution with a family-level biotic index. *Journal of the North American Benthological Society*, 7(1): 65-68.
11. Bode, R.W., M.A. Novak and L.E. Abele, 1996. *Quality Assurance Work Plan for Biological Stream Monitoring in New York State*. NYS Department of Environmental Conservation, Albany, NY., pp: 89.
12. Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling, 1999. *Rapid bioassessment protocols for use in streams and wade able rivers*. USEPA, Washington, D.C., pp: 841.
13. Hauer, F.R. and G.A. Lamberti, (Eds.), 2011. *Methods in stream ecology*. Academic Press., pp: 696.
14. Hilsenhoff, W.L., 1987. An improved biotic index of organic stream pollution. *Great Lakes Entomologist*, 20(1): 31-40.
15. Ostovan, H. and J. Niakan, 2005. Faunistic and biogenetic studies on aquatic beetles in southern and northern shores of Parishan Lake. *Journal of Agricultural Sciences*, 10(4): 93-116. (In Persian).
16. Ostovan, H. and J. Niakan, 2005. Faunistic and biogenetic studies on aquatic beetles in eastern and western shores of Parishan Lake. *Journal of Agricultural Sciences*, 11(3): 5-18. (In Persian).

17. Ostovan, H. and J. Niakan, 2008. Estimation of field biotic index and water quality of Shapoor River in Kazeroon region by using aquatic insects fauna. *Journal of Agricultural Sciences*, 13(3): 683-691. (In Persian).
18. Danesh, M., 2004. *Lake Biology*. Tehran. Center for Academic Publication, pp: 357. (In Persian).
19. Mandaville, S.M., 2002. Benthic Macro invertebrate in fresh water-Taxa Tolerance Values, Metrics and Protocols, project H-1, soil and water Conservation society of metro Halifax. xviii, pp: 48.
20. Peitz, D.G., 2003. Macroinvertebrate Monitoring as an Indicator of water Quality Status Report for Pipestone Creec, Pipstone National Monument, 1989-2002.
21. Navis, N. and W.N. Gillies, 2001. A comparison of a professional method and a volunteer method for assessing stream health, including discussion of an improved volunteer method. USEPA, s Rapid Bioassessment protocol II vs. West Virginia save our streams science and society, Number 2, Cacapon Institute, High view WV.
22. Badbareh, L., 1998. Study of Benthic organisms especially Diptera in Darke Evin's River. Fishery's bachelor thesis. Islamic Azad University. Iran.
23. Rezaii Pagherabad, 1998. Study of Macrobenthic in downstream of Karaj River (with emphasis on pollution), Fishery's bachelor thesis. Islamic Azad University. Iran.
24. Barji, M., 1999. Study of Jajrod River benthic organisms from Oshan until Fasham, Fishery's bachelor thesis. Islamic Azad University. Iran.
25. Hashemi, M., 2002. Plecoptera's biological cycle in Evin Darkeh's River. Fishery's bachelor thesis. Islamic Azad University. Iran.
26. Quinn, J.M. and C.W. Hickey, 1990. Characterization and classification of benthic invertebrate communities in 88 New Zealand rivers in relation to environment factors, *New Zealand Journal of Marine and Freshwater Research*.