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Taxonomy of benthic macroinvertebrates in Jajrud River for water quality assessment

F. Mehrjo[1], S.H. Hashemi[*1], A. Abdoli[2], F. Hosseinabadi[1]
[1]PhD candidate, Department of Environmental Pollutants Research, Environmental Sciences Research Institute, Shahid Beheshti University, Tehran, Iran
[2]Associate professor, Department of Biodiversity and Ecosystem Management, Environmental Sciences Research Institute, Shahid Beheshti University, Tehran, Iran

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Abstract

The invertebrates are one of the most important terrestrial fauna and freshwater taxa. Benthic macroinvertebrates include aquatic insects and spiders, mites, crustaceans, and species of mollusks and worms that are aquatic in their immature stages and terrestrial in their adult stage. Jajrud River originates from the Alborz Mountains and is a source of drinking water for people in eastern part of Tehran and the surrounding villages. For the taxonomic identification of benthic macroinvertebrates, five stations downstream of Jajrud were used. A Surber sampler device was used for sampling with dimensions 30 × 30 cm and mesh size of 250 microns in all four seasons of the year 2013 with three repetitions at each station. In total, five orders (Ephemeroptera, Coleoptera, Diptera, Trichoptera, and Oligochaeta) and 13 families of benthic macroinvertebrates were identified. In all stations, the family Baetidae (*Baetis sp*.) belonging to the order Ephemeroptera had the highest abundance, and seasonally the highest abundance was detected in autumn, winter, summer, and spring respectively. After the identification of benthic macroinvertebrates, five biotic indices including EPT, HFBI, SIGNAL, NJIS, and MMIF were calculated for water quality assessment in downstream of the Jajrud River. Regarding the results of the biotic indices, it can be said that the water quality of downstream of Jajrud River is not favorable. Therefore, appropriate management measures should be taken to improve river water quality.

Keywords: Downstream Jajrud, Benthic Macroinvertebrates, Sampling, Surber Sampler, Biotic Index.

[*]Corresponding author; h_hashemi@sbu.ac.ir

Introduction

The largest taxon of animals belongs to invertebrates which includes about 95% of all animal species. These animals are the most important terrestrial animals and fresh water taxa (Barnes et al., 2001). Benthic macroinvertebrates include aquatic insects and spiders, mites, shellfish, and a variety of mollusks and worms, which are aquatic in their immature stages and terrestrial in their adult stages and may live within or on river sediments. The body length of these animals is more than 0.5 mm. Aquatic insects with more than 500,000 species are the most abundant group, and spend at least one stage of their lives in water (Narf, 1997). In the food chain, benthic macroinvertebrates use the energy stored by plants and are available to larger animals such as fish. The benthic community in a healthy stream contains a variety of macroinvertebrates. Most are sensitive to pollution; in a polluted river, just a few of the large macroinvertebrates can be detected (Armitage et al., 1983). In general, in lentic waters, benthic macroinvertebrates play important role in the transition of matter and energy from primary producers and organic sediments to higher levels of the food chain. Normally, it takes time to use biological indicators for assessing the pollution and degradation caused by human activities. In fact, the diversity in the population of these organisms is high belonging to multiple branches with different food needs, growth, and reproductive cycles (Wetzel, 2001). Macroinvertebrates are an important component of aquatic ecosystems and have long been used to evaluate the water quality of streams. Among members of the aquatic ecosystem, they are probably best suited for water pollution monitoring, because they are numerous in almost every stream, are readily collected and identified, are not very mobile, and generally have life cycles of a year or more (Hilsenhoff, 1977). During the history of water quality assessment, based on biotic indices, at least one hundred indices have been observed. Over the past ten years, approximately 60% of these indices were based on the analysis of benthic macroinvertebrates (Czerniawska-Kusza, 2005). The use of benthic macroinvertebrates is based on the assumption that streams and rivers that are influenced by higher pollution pressures are less diverse in which the resistant species are dominant (Davies, 2001). Many studies have been conducted using benthic macroinvertebrates. In 2004, Hering et al. examined the assessment of rivers in Germany based on benthic macroinvertebrates. In 2008, Zilli et al. reviewed the collection of benthic macroinvertebrate functional feeding groups in the Parana River in Argentina. In 2011, Lock et al. used benthic communities as indicators to assess water quality in Bulgaria. In 2015, Melo et al. developed a multi-metric index based on aquatic macroinvertebrate communities to assess the water quality of rice fields in southern Brazil. In 2017, Graeber et al. examined multiple stress response of benthic macroinvertebrates in lowland stream depending on habitat type. The purpose of the current study was to explore and identify the taxonomy of benthic macroinvertebrates for water quality assessment in downstream Jajrud River in Tehran Province of Iran.

Materials and Methods

Study area

Jajrud River originates from heights of the Alborz Mountain in northern Tehran. The river is a source of drinking water for east Tehran and the surrounding villages along the river route. Because of the mountainous profile of the area and the problem of sewage disposal, all the waste water from the surrounding villages enter the Jajrud River. Along the river, waste disposal and solid waste can be seen. Jajrud as a small town is located to the south of the river. The river passes through Fasham village, arrives at Aoshan village where it is redirected to the southeast, follows the route of Rudaki and Lashkarak, enters Latyan Dam and the area which is called Jajrud. After that, the river flow ends at the Sharifabad Road after irrigating the Varamin plain. Part of the basin with an area of 692 square kilometers, which is located above the Latian dam on the Jajrud River, provides most of the water. For taxonomic identification of benthic macroinvertebrates in Jajrud, samples were taken downstream of the 5 stations in this area (Table 1) and Figure 1.

Table 1. Characteristics of sampling stations.

Station	Longitude	Latitude	Height from sea level (m)	Location of stations
Before Latyan Dam	51° 36' 58"	35° 48' 38"	1627	Recreational area
Najarkola	51° 38' 02"	35° 48' 36"	1641	Close to villas, and after Latyan Dam
Afjeh	51° 39' 48"	35° 49' 43"	1649	In the vicinity of the village and top branches
Bargjahan	51° 41' 48"	35° 48' 02"	1648	Top branches, Close to Forest Park
Saeidabad	51° 41' 40"	35° 44'28"	1456	Under Saeidabad bridges, after Latyan Dam and in the range of restaurant

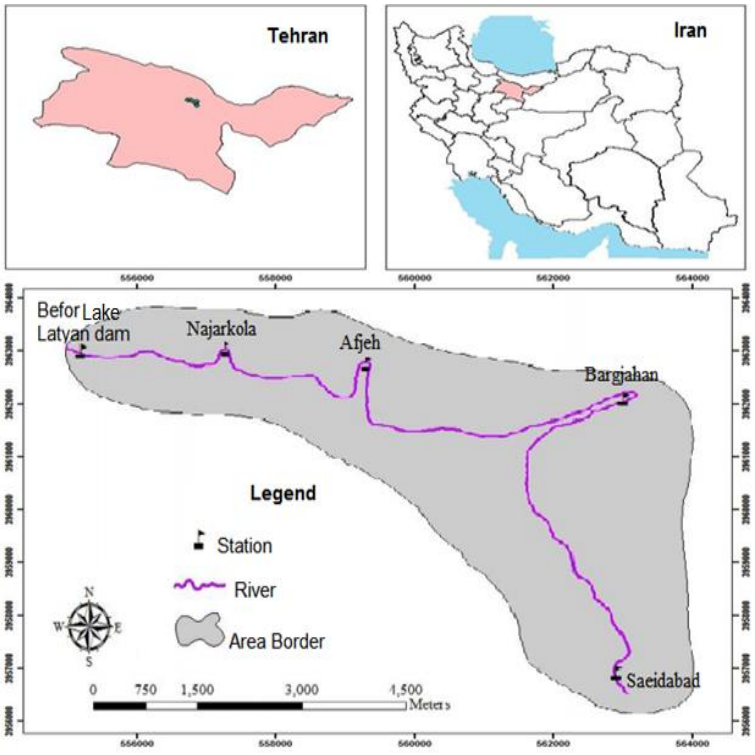

Figure 1. Location of sampling stations in the study area.

Sampling, isolation, identification, and counting of benthic macroinvertebrates

For sampling and identification of benthic macroinvertebrates in Jajrud River, the Surber Sampler device with area of 900 square cm (with dimensions 30 × 30 cm) and a mesh size of 250 microns was used during all four seasons of the year 2013 with three repetitions at each station. Then the samples were fixed with 4% formalin and transferred to the laboratory of Shahid Beheshti University of Tehran, Iran for isolation and identification. Using a benthic identification key (Tachet et al., 2000) benthic macroinvertebrates were identified and counted in terms of orders, families, and genera. Benthic macroinvertebrates of the order were poured into a penicillin glass and maintained with 96% alcohol.

Biotic indices for water quality assessment

After the identification of benthic macroinvertebrates, five biotic indices including EPT (Ephemeroptera, Plecoptera, and Trichoptera), HFBI (Hilsenhoff Family Biotic Index), SIGNAL (Stream Invertebrate Grade Number Average Level), NJIS (New Jersey Impairment Score), and MMIF (Multimetric Macroinvertebrate Index Flanders) were calculated for water quality assessment in downstream Jajrud.

Results and Discussion

The results included the identification of 3601benthic macroinvertebrates in the four seasons of sampling from five different stations downstream of Jajrud. Using the identification key, most benthic macroinvertebrates were identified at the genus level, and some of were identified at the family level (Table 2).

Table 2. Abundance of the identified benthic macroinvertebrate in sampling seasons.

Order	Family	Genus	Spring	Summer	Autumn	Winter
Ephemeroptera	Baetidae	*Baetis*	160	148	1067	786
	Heptageniidae	*Epeorus*	53	10	-	-
		Rhithrogena	-	25	1	5
	Caenidae	*Caenis*	8	38	26	1
Coleoptera	Elmidae	*Elmidae*	2	-	-	-
Diptera	Chironomidae	*Chronomus*	358	416	118	199
	Simuliidae		3	18	28	6
	Tipulidae	*Tipulidae*	4	3	1	-
	Psychodidae		1	5	-	-
	Empididae	*Hemerodromiinae*	-	-	23	10
	Limoniidae	*Pesdiciini*	-	-	2	1
	Limoniidae	*Limoniini*	-	-	-	2
Oligochaeta	Lumbericidae		1	5	30	32
Trichoptera	Hydropsychidae	*Hydropsyche*	-	1	5	-
	Total		589	669	1301	1042

A total of five orders and 13 families of benthic macroinvertebrates in Jajrud River were identified. Their abundance is shown in Figure 2 that covers five orders as follows: 1. Ephemeroptera, with three families and four genera; 2. Coleoptera, with one family and one genus; 3. Diptera, with seven families and five genera; 4. Trichoptera, with one family and one genus; and 5. Oligochaeta, with one family. It should be noted that, due to low river water levels during the summer, benthic macroinvertebrates sampling was not performed at the Bargjahan station. In the surveys, aquatic insects with four orders were identified of which the benthic fauna in Jajrud River was the dominant group, similar to other studies (Jalili et al., 2010; Girgin, 2010; Alonso and Camargo, 2010). The highest abundance of benthic macroinvertebrate was found in autumn, winter, spring, and summer, respectively. Seasonally, the highest abundance of benthic macroinvertebrate was seen in autumn because of their cycle, and their while in spring due to the increased water velocity and high river discharge, their abundance was low (Augiar and Ferreira, 2002). The highest benthic macroinvertebrates diversity was detected at Afjeh station. This might be due to addition of twigs from trees top branches, orchards, wheat fields and a lower resident population in the Afjeh district than other stations. In all of the stations studied, the family Baetidae (Baetis sp.) of the order Ephemeroptera had the highest abundance of benthic micro-invertebrates. The family

with the highest abundance in autumn was found before Latyan dam station. The results of a study by Yadollahi et al. (2010) corresponded with the results of the current study. Given that the family is a taxon that has moderate resistance to pollution, the high abundance of these taxa may indicate that the water quality is relatively poor. Also the minimum benthic micro-invertebrate abundance was seen in Elmidae family of the order Coleoptera and Psychodidae family of the order Diptera. The amounts of benthic organisms from the highest to the lowest were found in stations before Latyan dam, Afjeh, Bargjahan, Najarkola, and Saeidabad, respectively. The high abundance of benthic micro-invertebrates in stations before Latyan dam can be attributed to the presence of vegetation around this station. Vegetation in different stages of the benthic life cycle could be considered an important determining factor. Plants are also important in terms of the food supply, and affect the quality and variety of organisms in a region (Mackie, 1988).

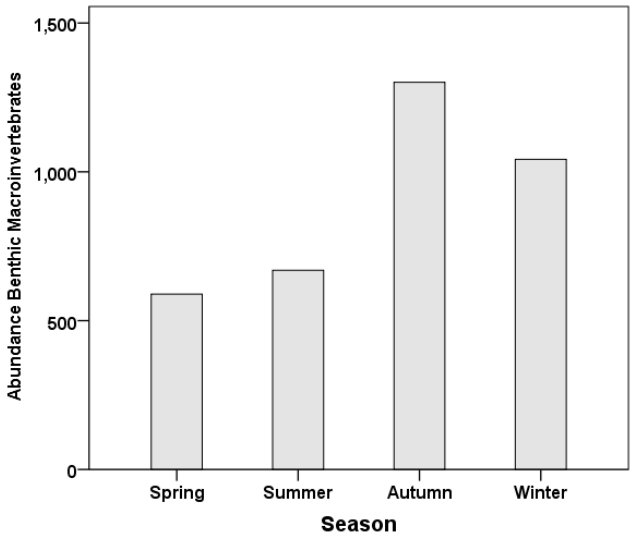

Figure 2. Seasonal abundance of benthic macroinvertebrates.

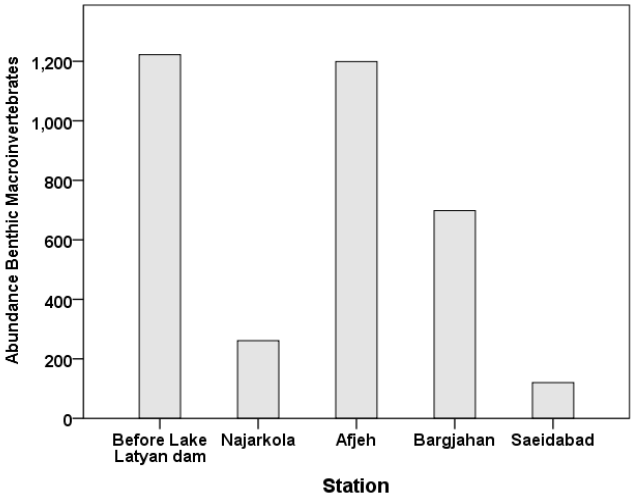

Figure 3. Spatial abundance of benthic macroinvertebrate in sampling stations.

A statistical description of benthic macroinvertebrate in sampling seasons is shown in Table 3.

Comparison of biotic indices in sampling stations is shown in Figure 4. The EPT index consists of three orders

Ephemeroptera, Plecoptera, and Trichoptera. This index shows the order of aquatic insects that are susceptible to contamination (Mandaville, 2002). According to this index, water quality was evaluated in most stations as contaminated. The HFBI index evaluated the water quality based on the resistance of benthic macroinvertebrates families to pollution from zero (excellent) to 10 (very weak) (Mandaville, 2002). Based on this index, water quality was evaluated as average to good in most stations. The SIGNAL index for water pollution is based on tolerance or intolerance of benthic macroinvertebrates. This index assesses water quality from 1 (low pollution) to 10 (high pollution) (EPA Victoria, 2004). Based on this index, water quality was evaluated in most stations as low to moderately polluted. The MMIF index is for the assessment of the water quality in the rivers of Belgium. This index classifies river water quality as very good, good, moderate, weak, and bad (Gabriels et al., 2010). In all sampling seasons and stations, water quality assessment was weak and bad according to the MMIF index. The NJIS index is developed in New Jersey, USA, and evaluates the water quality in three classes including without disturbance, moderate disturbance, and severe disturbance (Kurtenbach, 1991). In the study area, two classes of moderate and severe disturbance were observed. Saeidabad station had the least abundance of benthic micro-invertebrates. Considering that Saeidabad station is located past Lake Latyan dam, the hydrological conditions, movement of sediment, and water quality causes changes in habitat, abundance, and diversity of benthic micro-invertebrates at this station compared to those before the dam. The abundance of benthic fauna at the Brgjahan station was high, because it is located in the Forest Park area. Najarkola station also had a low benthic abundance, because of its vicinity to residential areas and the low amount of vegetation around this station.

Table 3. Statistical description of benthic macroinvertebrate in sampling seasons.

Statistical Description	Spring	Summer	Autumn	Winter
Mean	65.56	66.90	130.10	115.78
Median	4	14	24.50	6
Mode	1	5	1	1
Std. Deviation	121.44	130.28	331	259.31
Variance	14748.78	16972.93	109563.66	67243.44
Skewness	2.19	2.62	3.10	2.70
Kurtosis	4.65	7.01	9.70	0.72
Range	357	415	1066	758
Minimum	1	1	1	1
Maximum	358	416	1067	786
Percentiles (25%)	1.5	4.5	1.75	1.5
Percentiles (50%)	4	14	24.50	6
Percentiles (75%)	106.50	65.50	52	115.50

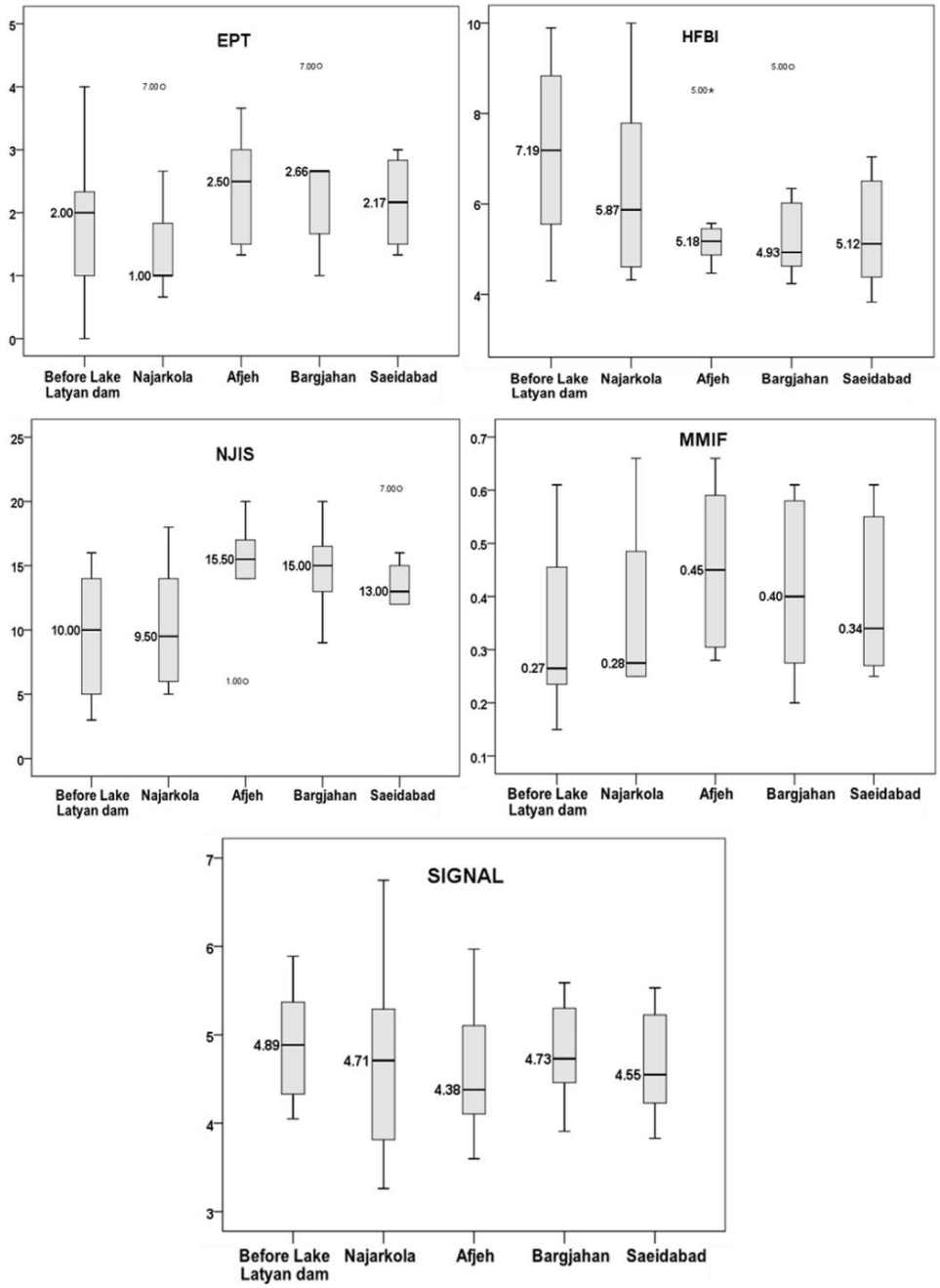

Figure 4. Comparison of biotic indices in sampling stations.

Conclusion

Benthic macroinvertebrates are important organism in aquatic ecosystems. These animals in lentic waters play important role in the transfer of organic sediments and the primary production to higher levels of the food chain and are found within the sediments. In total, five orders and 11 families of benthic macroinvertebrates and fauna were identified. According to the benthic macroinvertebrates life cycle and reproductive conditions, they are most abundant in autumn and least abundant in spring. Where sufficient vegetation around sampling stations of the benthic macroinvertebrates exists, these benthic faunae become more abundant, because vegetation plays an important role in their feeding. According to the results,

downstream of Jajrud River is not in a desirable situation. Given the importance of Jajrud River as a source of drinking water in Tehran, appropriate managerial and executive actions must be taken to improve water quality in this river.

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