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SEASONAL IDENTIFICATION OF MACROBENTHOS IN THE JAJROOD RIVER

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ABSTRACT

The present study aimed to identify seasonal macrobenthos abundance in the Jajrood River. The diversity of macrobenthos in the Jajrood River was identified and studied at five stations in the autumn and winter of 2014 and spring and summer of 2015. The geographical location of each station was determined by GPS. Samples were collected and examined seasonally. Five orders, 15 families, 17 genera, and 19 species of macrobenthos were identified in the study conducted in the Jajrood River. The highest and the lowest frequencies belonged to Insecta and Crustaceae with 72% and 0.2% of the total frequency, respectively, among the five orders identified in the Jajrood River. Among the identified species, *Chironomus* sp. and *Tipula* sp. with total frequencies of 865 and 3 per square meter, respectively, presented the highest and the lowest abundances. The density of macrobenthos fluctuated in the autumn and winter with maximum and minimum densities of 1073 and 801 per square meter, respectively. The families identified in this sampling belonged to the orders Insecta (9), Gastropoda (2), Malacostraca (1), Cructaceae (1), and Oligochaeta (2).

KEYWORDS: Macrobenthos, annelids, arthropods, mollusks, Jajrood River

INTRODUCTION

Macrobenthos are invertebrates that are visible to the naked eye and spend at least part of their life cycles on the beds of water bodies (Arimoro 2011). Benthic organisms are among the living components of the aquatic ecosystem that play an important role in the balance of the relevant ecosystem by playing various roles. These organisms account for part of the food chain of many aquatic species, especially fish, and thus affect the energy and nutrient cycle. Benthic organisms mineralize organic matter, are used by other aquatic organisms as the second or third trophic level, and are an indicator of the total production rate and an indicator of water quality (Ansari, 1994). Different seasons of the year are another factor affecting the distribution and density of macrobenthos. The changes that occur in cold seasons compared to warm seasons are mainly caused by the decrease in temperature and the increase in pressure (Jorjani, 2010). In winter, low sunlight and snow prevent photosynthesis. This process, along with the respiration of organisms and the lack of oxygen from the atmosphere into the water, causes oxygen depletion in the water. Typically, oxygen depletion occurs in early April, particularly at the bottom as the habitat of macrobenthos. In spring, the sun is higher and the days are longer. As the water surface warms and reaches 4 °C, the water becomes heavier and sinks to the bottom of the river. This movement causes transition currents in the river, which makes the conditions favorable for the life, reproduction, and growth of macrobenthos. In summer, when the weather becomes warmer and the water temperature rises, conditions are good for the growth and reproduction of macrobenthos until August, after which macrobenthos cannot tolerate high temperatures, preventing their reproduction and proliferation. The angle of sunlight decreases, the days become shorter, and cold weather begins with the onset of autumn. The wind forms currents that transport colder, more oxygen-rich water to the depths of the river, again resulting in unfavorable living conditions for macrobenthos and other aquatic organisms. Therefore, the distribution of oxygen and temperature at different depths can affect the distribution of the animal community, including river macrobenthos (Qasemzadeh, 2011). The species diversity of macrobenthos decreases due to the increase in water flow rate in cold seasons. A higher river water flow rate hinders macrobenthos establishment, which reduces the species diversity of macrobenthos. Environmental conditions, especially water flow rate, greatly affect the diversity and density of macrobenthos in rivers, which is dramatically significant during flood seasons. Massive and violent floods in late autumn and during winter cause the removal and destruction of these beds, which carry along the macrobenthos to places far away from their original location (Pazira et al., 2008). Although some organisms are found in all temperature conditions, flatworms are often seen in cold waters. Mollusks are filter-feeding organisms and cannot tolerate high water turbidity because high turbidity prevents these organisms from feeding (Bhosale, 2012). According to the literature, the first study of seabed organisms was conducted in 1918 by a Danish biologist who studied benthic communities in the Danish seas, aiming to determine the role of benthos as fish food in the food chain (Castro, 2000). Hatami et al. (2011) studied the abundance, diversity, dominance, and richness of macrobenthos in Madarsoo Stream of Golestan National Park. According to the results, individuals of the orders Ephemeroptera showed the highest abundance (62%), and the lowest abundance (< 1%) belonged to Pelecoptera and Amphipoda among different orders in this stream. Toosi et al. (2010) studied the population structure of macrobenthos in six springs (Qalae Dibaj, Sarchemeh Dibaj, Ab Sij, Ab Rendan, and Kalateh Pirkhosh) in the north of Damghan County. They identified a total of 11 orders and 18 families. Since the majority of the observed samples belonged to four orders: Diptera, Ephemeroptera, Amphipoda, and Hymenoptera, the results were estimated for these four orders. Seasonal study of the order Amphipoda showed that the maximum and minimum frequencies of the order were in winter and spring, respectively. In the same seasonal study, the order Ephemeroptera showed the maximum and minimum frequencies in spring and summer, respectively. The seasonal study also indicated the maximum and minimum frequencies of the order Diptera in autumn and summer, respectively. In the seasonal study, the maximum and minimum frequencies of the order Hymenoptera were reported in summer and spring, respectively.

Factors affecting the distribution and density of benthic organisms are largely interconnected and related to each other. In an aquatic ecosystem, environmental factors, such as physicochemical factors, organic matter content in the substrate, the type of substrate sediments, dissolved oxygen content in sediments, feeding habits of benthic organisms, and the effects of physical stability bioturbation play an important role in the expansion and dispersion of benthic communities (Mousavi Nadoushan, 2011). As mentioned above, the present study aimed to identify seasonally the macrobenthos in the Jajrood River.

MATERIALS AND METHODS

Sampling stations and their characteristics:

Using the Jajrood River map (Fig. 1) and information on the geographical location (Table 1) to evaluate the area, the first station as a control was selected in the upstream area of the Jajrood River. The second station was chosen 2 km from station 1 at the inflow of lentic water to the Jajrood River. The third station was designated before the Latyan Dam to measure and examine the quality of the water entering the dam. The fourth station after the Latyan Dam was selected to assess the impact of the dam on water quality and the self-purification ability of water inside the dam along the Jajrood River after the river discharge from the dam. The fifth station was chosen to investigate the impact of urban pollutants on the water quality of the Jajrood River within the city of Jajrood.

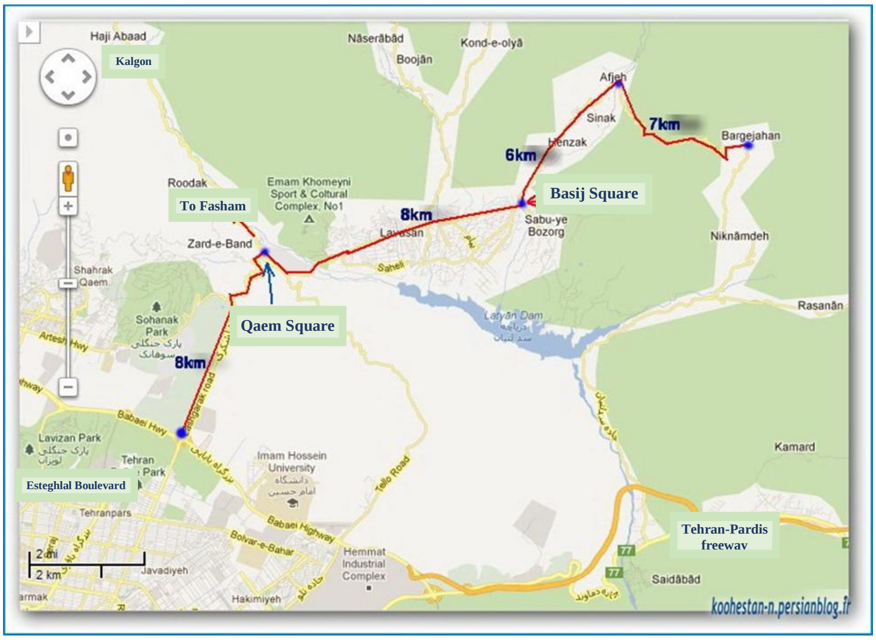

Figure 1. Map of the Jajrood River

Table 1. Geographical locations of the studied stations

Title	Location	Longitude	Altitude
Station 1	Upstream the Jajrood River	51.696541 E	35.748943 N
Station 2	Lentic water inflow to the Jajrood River 2 km from Station 1	51.695940 E	35.746222 N
Station 3	Before the Latyan Dam	51.685852 E	35.794904 N
Station 4	After the Latyan Dam	51.692940 E	35.765840 N
Station 5	Within the city of Jajrood	51.694109 E	35.740990 N

Sampling method:

Samples were collected seasonally from the designated stations along the Jajrood River in the autumn and winter of 2014 and spring and summer of 2015, once in the last month of each season. The geographical characteristics of the stations were determined using GPS and recorded on the map. It should be noted that the five stations were selected based on the river characteristics, such as vegetation cover, water flow velocity, river slope, and the entry of pollutants. At each station, samples were taken from three points on the banks and in the middle of the river using a quadrat sampler measuring 50 × 50 cm. Then, sampling operations were carried out at each station as follows.

RESULTS

Our study in the Jajrood River identified five orders, 15 families, 17 genera, and 19 species of macrobenthos. The identified classes were Insecta (72%), Oligochaeta (4.8%), Malacostraca (3.2%), Gastropoda (1.9%), and Crustaceae (0.2%) among the total collected samples. The families identified in this sampling belonged to the orders Insecta (9), Gastropoda (2), Malacostraca (1), Cructaceae (1), and Oligochaeta (2). The density of macrobenthos fluctuated in autumn and winter with maximum and minimum densities of 1073 and 801 per square meter, respectively. Among the identified genera, *Chironomus* was more frequent (865 individuals/m^2 and 21.18% of the total frequency), and the lowest frequency belonged to the genus *Tipula* with a frequency of three individuals/m^2 and 0.07% of the total frequency. Both genera belonged to the order Diptera and the class Insecta.

In this sampling, the air temperature varied from about 38 °C in summer to 8 °C in winter, with an average of 23 °C. The water temperature varied from about 26 °C in summer to about 0 °C in winter, with an average of 13 °C.

1. Abundance and distribution of species identified in the Jajrood River in autumn 2014

Thirteen families and 12 genera belonging to five orders, Gastropoda, Oligochaeta, Malacostraca, Insecta, and Crustaceae, were identified in autumn, with a total identified specimens of 1090/m^2. The highest (433/m^2) and the lowest (23/m^2) numbers were recorded at station 3 and station 5, respectively. In the identified stations, Insecta was more frequent (784/m^2 and about 71.9% of the total abundance), and Gastropoda was least abundant (19/m^2 and about 1.7% of the total population). Among the insects identified in this season, the order Diptera showed the highest abundance (531/m^2 and about 48.7% of the total abundance), and the lowest abundance (19/m^2 and about 1.7% of the total population) belonged to the order Prosobranchiata. Among the Insecta identified in autumn, *Chironomus* sp. was most abundant (400/m^2 and about 36.6% of the total abundance), and *Haliplus fluviatilis* marked the lowest abundance (2/m^2 and about 0.1% of the total population). Among the identified Gastropoda, *Valvata cristata* possessed a frequency of 15/m^2 and about 1.3% of the total abundance, and *Limnaea truncatula* showed a frequency of 4/m^2 and about 0.3% of the total abundance.
In the order Malacostraca, *Potamon fluviatile* (with 12/m^2 and about 1.1% of the total frequency and *P. potamios* (with 101/m^2 and about 2.9% of the total frequency) were respectively the lowest and highest populations. In the order Oligochaeta, the highest and the lowest populations belonged to *Lumbricus terrestris* (with 156/m^2 and about 14.3%) and *Tubifix* (with 8/m^2 and about 0.7%), respectively. In the order Crustaceae, the only identified species was *Asellus aquaticus* with a frequency of 10/m^2 and about 0.9%.

2. Abundance and distribution of species identified in the Jajrood River in the winter of 2014

Seven families and nine genera belonging to four orders, Malacostraca, Gastropoda, Oligochaeta, and Insecta, were identified in winter. In total, 801 specimens per square meter were identified in winter. The highest and the lowest numbers were detected at station 1 (256/m^2) and station 5 (16/m^2). In the identified stations, Insecta (570/m^2 and about 71.1% of the total abundance) and Gastropoda (3/m^2 and about 0.3% of the total population) possessed the highest the lowest abundances, respectively.

In the identified Insecta, the highest (295/m^2 and about 36.8% of the total abundance) and the lowest (275/m^2 and about 34.3% of the total population) belonged to orders Diptera and Ephemeroptera, respectively. Among the Insecta species identified in winter, *Chironomus* sp. had the highest abundance (239/m^2 and about 29.8% of the total abundance), and *Simulium* sp. had the lowest abundance (with 35/m^2 and about 4.3% of the total population).

In Gastropoda, *L. truncatula* with an abundance of 3/m^2 and a percentage of 0.3 was the only species identified in this season. In Oligochaeta, *L. terrestris* was the only identified species with an abundance of 143/m^2 and a percentage of 17.8. In Malacostraca, *P. potamios* presented the highest abundance (64/m^2 and a frequency of about 7.9%), and *P. fluviatile* showed the lowest abundance (21/m^2 and a frequency of about 2.6%) of the total population.

3. The abundance of species identified in the Jajrood River in the spring of 2015

Thirteen families and 12 genera belonging to four orders, Gastropoda, Malacostrata, Oligochaeta, and Insecta were identified in spring, with a total identified specimens of 1039/m^2. Station 4 (with 378/m^2) and station 5 (with 26/m^2) possessed the highest and the lowest abundances, respectively. In the identified stations, Insecta (with 742/m^2 and about 71.4%) and Gastropoda (with 12/m^2 and about 1.1%) were the most frequent classes, respectively.
Among the Insecta classes identified in this season, *Chironomus* sp. (226/m^2 and about 21.7% of the total abundance), and *Gomphus vulgatissimus* (2/m^2 and about 0.1% of the population) showed the highest and the lowest abundances, respectively.

In the Gastropoda class, the highest (11/m^2 and about 1% of the total) and the lowest (1/m^2 and about 0.09% of the total) abundances belonged to *Valvata cristata* and *L. truncatula*, respectively. In the Oligochaeta class, *L. terrestris* (168/m^2 and about 1.16%) and *T. tubifix* (5/m^2 and about 0.4%) possessed the highest and the lowest frequencies, respectively. In the Malacostraca class, *P. potamios* had the highest abundance (71/m^2 and about 51.07%), and *P. floviatile* was least abundant (41/m^2 and about 3.9%).

4. Frequency and distribution of species identified in the Jajrood River in the summer of 2015

Nine families and nine genera belonging to three orders, Insecta, Malacostraca, and Oligochaeta, were identified in summer, with a total number of 921/m^2. The highest and the lowest numbers were counted at station 1 (323/m^2) and station 5 (19/m^2), respectively. In the identified stations, Insecta (with 619/m^2 and about 67.2% of the total) and Oligochaeta (with 130/m^2 and about 14.1%) presented the highest and the lowest frequencies, respectively.
Among the identified Insecta, *Caenis rivulorum* from the order Diptera and *Chironomus* sp. from the order Ephemeroptera had the highest frequency (146/m^2 and about 15.8%), and *Tipula* sp. from the order Diptera had the lowest frequency (3/m^2 and about 0.3%). Among the identified Malacostraca, *P. potamios* (with 108/m^2 and about 11.7%) and *P. fluviatile* (with 64/m^2 and about 6.9%) were the most and least frequent species, respectively. Among the Oligochaeta, *L. terrestris* (with a frequency of 130/m^2 and about 14.1%) was the only identified species.

Table 2. Species identified in the Jajrood River in the autumn and winter of 2014 and spring and summer of 2015

Phylum	Class	Order	Family	Genus	Species
Arthropoda	Insecta	Diptera	Simuliidae	*Simulium*	*Simulium* sp.
			Chironomidae	*Chironomus*	*Chironomus* sp.

				Spaniotoma	*Spaniotoma* sp.
			Limoniidae	*Tipula*	*Tipula* sp.
		Ephemeroptera	Caenidae	*Caenis*	*Caenis moesta*
					Caenis rivulorum
			Baetidae	*Baetis*	*Baetis rhodani*
		Odonata	Gamphidae	*Gomphus*	Gomphus vulgatissimus
		Coleoptera	Haliplidae	*Haliplus*	*Machronychus glabratus*
				Elmis	*Elmis maugei*
			Elmidae	*Macronychus*	*Macronychus glabratus*
		Hemiptera	Gerridae	*Gerris*	*Gerris najas*
Mollusca	Gastropda	Prosobranchiata	Valvatidae limnaeidae	*Valvata*	*Valvata cristata*
				Limnaea	*Limnaea truncatula*
Arthropoda	Malacostraca	Decapoda	Potamidae	*Potamon*	*Potamon fluviatile*
					Potamon potamios
	Crustaceae	Isopoda	Asellidae	*Asellus*	

					Asellus aquaticus
Annelida	Oligochaeta	Haplotaxida	Lumbricidae	*Lumbricus*	*Lumbricus terrestris*
			Tubificidae	*Tubifex*	*Tubifex tubifex*

The changes in different classes in the Jajrood River in different seasons are presented in Figure (2). According to this figure, the Insecta class has the highest change, and the Gastropoda and Crustaceae classes show the lowest changes in the Jajrood River in different seasons.

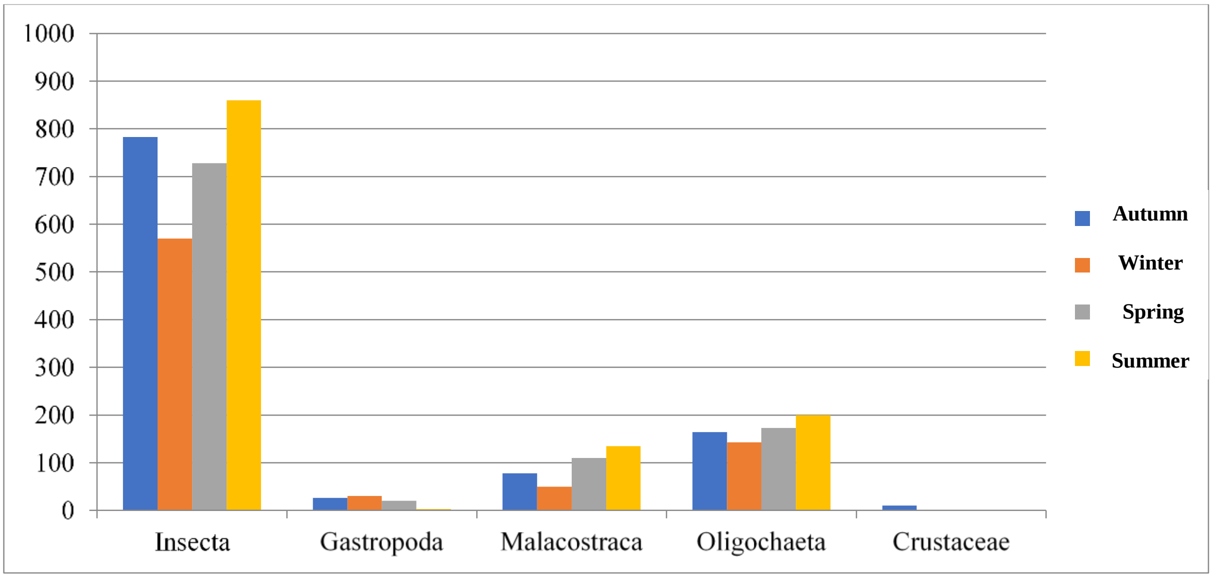

Figure 2. Changes in the identified taxa in the Jajrood River in different seasons during 2014-2015

Table 3. The frequency percentage of identified genera in the Jajrood River in all seasons

Genera	Frequency	Percentage
Simulium	168	4.3
Chironomus	1003	26.2
Spaniotoma	100	2.6
Tipula	3	0.07
Caenis	901	23.5
Baetis	462	12.09
Gomphus	7	0.18
Haliplus	13	0.34
Elmis	8	0.20
Gerris	11	0.28
Valvata	26	0.68
Limnaea	8	0.20
Potamon	472	12.3
Asellus	10	0.26

Lumbricus	596	15.6
Tubifex	13	0.34
Macronychus	10	0.26

The highest and lowest frequencies of identified species belonged to *Chironomus* sp. and *Tipula* sp., respectively, throughout the year (Table 4).

Table 4. The highest and lowest frequencies of identified species in different seasons in the Jajrood River during 2014-2015

Season	Species			
	Most abundant	N	Least abundant	N
Autumn 2014	*Chironomus* sp.	400	*Haliplus fluviatilis*	2
Winter 2014	*Chironomus* sp.	239	*Limnaea truncatula*	3
Spring 2015	*Chironomus* sp.	226	*Limnaea truncatula*	1
Summer 2015	*Chironomus* sp.	148	*Tipula* sp.	3

The abundance of identified species in the Jajrood River in autumn revealed that the highest ($400/m^2$ and a frequency percentage of 37.3%) and the lowest ($2/m^2$ and a frequency percentage of 0.2%) abundances belonged to *Chironomus* sp. and *Haliplus fluviatilis*, respectively (Table 5).

Table 5. Species identified at five stations in the Jajrood River in the autumn

Row	Species	Station 1	Station 2	Station 3	Station 4	Station 5
1	*Simulium* sp.	+	_	_	_	_
2	*Chironomous* sp.	+	+	+	+	_
3	*Caenis moesta*	+	+	_	+	_
4	*Caenis rivulorum*	+	+	_	+	_
5	*Baetis rhodani*	+	+	_	+	_
6	*Valvata cristata*	+	+	_	+	_
7	*Limnaea truncatula*	+	_	_	_	_
8	*Potamon fluviatile*	+	+	_	+	_
9	*Potamon potamios*	+	+	_	+	+
10	*Lumbricus terrestris*	+	+	+	+	_
11	*Haliplus fluviatilis*	_	+	_	_	_
12	*Gamphus vulgatissimus*	_	+	_	_	_
13	*Asellus aquaticus*	_	+	_	_	_
14	*Gerris najas*	_	_	+	_	_
15	*Spaniotoma* sp.	_	_	+	_	_
16	*Tubifix tubifix*	_	_	_	_	+

Table 6. Species identified at five stations in the Jajrood River in the winter

Row	Species	Station 1	Station 2	Station 3	Station 4	Station 5
1	*Simulium* sp.	+	_	_	+	_
2	*Chironomous* sp.	+	+	+	+	+
3	*Caenis moesta*	+	_	_	+	_
4	*Caenis rivulorum*	+	+	_	+	_
5	*Baetis rhodani*	+	+	_	+	_
6	*Limnaea truncatula*	+	_	_	_	_
7	*Lumbricus terrestris*	+	+	+	+	+
8	*Potamon fluviatile*	+	+	_	+	_
9	*Potamon potamios*	+	+	_	+	_

Table 7. Species identified at five stations in the Jajrood River in the spring

Row	Species	Station 1	Station 2	Station 3	Station 4	Station 5
1	*Gerris najas*	+	_	+	_	_
2	*Haliplus fluviatilis*	+	_	_	_	_
3	*Gamphus vulgatissimus*	+	_	_	_	_
4	*Caenis moesta*	+	+	_	+	_
5	*Caenis rivulorum*	+	+	_	+	_
6	*Baetis rhodani*	+	+	_	+	_
7	*Chironomous* sp.	+	+	+	+	+
8	*Simulium* sp.	+	_	_	+	_
9	*Valvata cristata*	+	_	_	+	_
10	*Limnaea truncatula*	+	_	_	_	_
11	*Lumbricus terrestris*	+	+	_	+	+
12	*Potamon fluviatile*	+	_	_	+	_
13	*Potamon potamios*	+	+	_	+	+
14	*Machronychus glabratus*	_	_	_	+	_
15	*Elmis manugei*	_	_	_	+	_
16	*Tubifix tubifix*	_	_	_	_	+

Table 8. Species identified at five stations in the Jajrood River in the summer

Row	Species	Station 1	Station 2	Station 3	Station 4	Station 5
1	*Haliplus fluviatilis*	+	+	-	-	-
2	*Gamphus Vulgatissimusn*	+	+	-	-	-

3	*Caenis moesta*	+	+	-	+	-
4	*Caenis rivulorum*	+	+	-	+	-
5	*Baetis rhodani*	+	+	-	+	-
6	*Tipula sp.*	+	-	-	-	-
7	*Chironomous sp.*	+	+	+	+	+
8	*Simulium sp.*	+	+	+	+	-
9	*Lumbricus terrestris*	+	+	-	+	+
10	*Potamon fluviatile*	+	+	-	+	-
11	*Potamon potamios*	+	+	-	+	+

DISCUSSION AND CONCLUSION

This study investigated the abundance and distribution of macrobenthos in the Jajrood River. Different frequencies were obtained in different seasons, fluctuating from a minimum of 801 individuals/m^2 in winter to a maximum of 1073 individuals/m^2 in autumn. This study was conducted at five stations in the Jajrood River during four seasons, autumn and winter 2014 and spring and summer 2015, respectively.

Stations 1 (upstream of the river), 2 (inflow of stagnant water into the river near station 1), and 4 (after the Letitan Dam) were cleaner than stations 3 and 5. The presence of the genera *Baetis*, *Elmis*, and some genera from the order Ephemeroptera in these three stations indicated the relative cleanliness of these stations. These genera are lower elevation indices and are usually widely distributed in lotic waters; they usually do not withstand oxygen-deficient conditions and sewage pollution.

The presence of the genera *Simulidae*, *Shironomididae*, and *Asellus*, along with pollution-sensitive taxa, indicates that the entry of organic matter into the river water does not significantly affect the river water quality in these three stations. The absence of various genera in Station 3 (inside Jajrood City) and 5 (behind the Letian Dam) and the presence of Chironomids in these two stations indicate the presence of some degree of pollution in these stations. Moreover, the presence of the family Tubificidae in Station 5 suggested the contamination of this area with organic matter because *Tubifex* worms are found in soft sediments rich in organic matter. Some worms of this species actively seek habitats with organic pollution and low oxygen. In Stations 1, 2, and 4, the presence of various genera, especially pollution-sensitive genera, indicates no entry of toxic substances into the river in these three stations. However, the sources of pollutants affecting the river water quality were visible around the river, especially in Stations 3 and 5 and to some extent in Station 4, as they were available to the public.

In a study on the biological assessment of the Kashkan River based on the diversity and population structure of macrobenthos, the results showed that seasonal changes in the density of identified organisms indicated maximum and minimum densities in spring and winter, respectively (Heydari et al., 2012). Elsewhere, the effects of sand and sand factory effluent were investigated on biological and environmental indicators of the Tirum River. On average, the highest and the lowest densities of macrobenthos were recorded in August and November, respectively (Bagheri Tavani et al., 2012).

Heydari et al. (2012) identified 26 families of benthic invertebrates in 10 orders, among which Chironomidae, Simuliidae, and Baetidae were the dominant families, respectively. In the study by Eshaghi Neimuri et al. (2012), the highest percentage of abundance belonged to the orders Diptera and Ephemeroptera, respectively. Mirrasouli and Ghorbani (2011) identified 14 orders and 81 groups (genera and families) of large benthic invertebrates. Soleimani-Rad et al. (2011) identified 60 families of benthic invertebrates, belonging to 18 orders and seven classes.

Shiroud Mirzaei (2011) documented 33 families and 22 genera of large macrobenthos, among which the highest diversity and abundance belonged to aquatic insect larvae (orders Diptera, Ephemeroptera, and Plecoptera). Tabatabai et al. (2009) showed that a total of 14 species belonging to six orders of benthic invertebrates were identified in the region. The highest percentage of invertebrate abundance belonged to Polychaeta, Bivalvia, Gastropoda, Decapoda, and Isopoda, respectively. Pazira et al. (2008) found that Ephemeroptera showed the highest relative abundance at station 1, which was not observed at station 7, in which the highest relative abundance was recorded for Diptera. Hatami et al. (2011) reported that the identified macrobenthos belonged to 53 families from 16 orders and 11 classes.

It is suggested to raise the importance of preserving and protecting aquatic ecosystems at different levels of society through mass communication and mass media, as well as educating on environmental issues using various educational technologies.

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