

A RESEARCH ON DETERMINATION OF HABITAT QUALITY OF RUNNING WATERS OF WESTERN BLACK SEA REGION USING BY BENTHIC MACROINVERTEBRATES

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Abstract

In this study, benthic macroinvertebrate fauna of running waters of western Black Sea Region was studied in Düzce, Bolu, Karabük, Kastamonu and Sinop. Physico-chemical variables and biological data were collected from various running water ecosystems in this region. The benthic macroinvertebrate samples consisted of seven classes which were Platyhelminthes, Gastropoda, Bivalvia, Oligochaeta, Arachnida, Malacostraca and Insecta. Benthic macroinvertebrates in various taxonomic levels were used in determination of water quality.

The relationships between macroinvertebrate assemblages and some environmental variables were explored by various statistical analysis and indices. The dominance and similarity index was used for the numerical analysis of benthic macroinvertebrates. According to physico-chemical variables, biotic index and number of EPT taxa, sampling sites were detected unpolluted, slightly polluted and moderately polluted.

Keywords: *running water, ecosystem, biomonitoring, benthic macroinvertebrates, Western Black Sea Region, physico-chemical variables, habitat quality.*

Introduction

Ecosystem and physical habitat destruction, degradation of water quality, changes in species distribution or extinction and decrease in diversity are unfavourable changes in running waters. In many countries, long-term monitoring studies are maintained and rapidly increase to prevent these effects (Kazancı, 1999; Kazancı and Girgin, 2001). Researches have mostly accentuated physical and chemical methods in Turkey. However biological methods and physico-chemical methods must be maintained and considered together for obtaining long-term results (Kazancı et al. 1997). Biomonitoring is a consolidative method to determine causes which arise on account of physical, chemical and biological variables. Indicators of study area must be determined in this method (Ellenberg et al. 1991). Benthic macroinvertebrates are used as indicators in biomonitoring because they are sensitive to changes in physical and chemical variables of ecosystems and reflect habitat quality with their affected abundance and community structures (Cairns and Dickson, 1971).

Benthic macroinvertebrates which are sensitive to environmental changes and used as biological parameter to determine water quality in this research. Water quality of sampling sites were detected between class I and III which indicates unpolluted, slightly polluted or moderately polluted waters. This research aimed at determining fauna of benthic macroinvertebrates and the relationships between their distribution and habitat quality characteristics of running waters in western Black Sea Region. The results of ecological changes were detected in diversity, dominance, similarity, EPT taxa number and community structure with this emphasis. Additionally, the Belgian Biotic Index (BBI) (De Pauw and Vanhooren, 1983) was used for assessment of habitat quality.

Study area

Western Black Sea Region is situated in the northwest of Turkey (Fig. 1). Total area of research region is about 484 km². The geologic structure have been formed with North Anatolian Mountains which were formed as a result of Alpine curves in III. geological period. In this region, mountains reach to coastline in paralel. The climate of iner parts of this region is continental and the climate is maritime at coastline, specific Black Sea climate. The mean annual temperature of the air is between 13 and 15°C. The main annual precipitation amount is 1000-1500 mm. Maximal precipitation falls in autumn, minimal precipitation falls in spring.

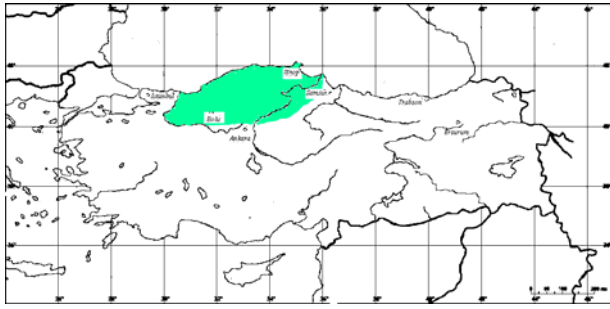


Figure 1. Location of study area.

Materials and methods

This study was conducted in June 2006. Sampling was carried out at 15 sites from various running waters in research area (Fig. 2). Sampling sites were chosen from areas which were faraway from settlements, cultivated areas and degraded areas for the aim of high diversity. Altitudes of sampling sites from highland area were between 55 and 1467 m. Some characteristics like flow, stagnation, shaded or sunny areas, vegetation and bottom structure with stone, gravel or sand were considered in sampling sites on running waters.



Figure 2. Sampling sites chosen from running waters of Western Black Sea Region (coloured with BBI classes).

Physico-Chemical Characteristics

At each sites, physical (temperature, vegetation, width, bottom structure exct.) and chemical (pH, dissolved oxygen, conductivity, salinity) characteristics were determined at the same time as sampling of macroinvertebrates. Temperature, pH, dissolved oxygen, conductivity and salinity measurements were carried out using YSI 63 Multiprobe System and YSI 550. Some physical characteristics of the sampling sites were given in Table 1.

Macroinvertebrates

Each benthic macroinvertebrate samples were collected by kicking for 45 minutes at 15 sampling sites with a standart kick-net. Samples were preserved in 80 % ethly alcohol. Taxa were identified to the practicable lowest taxonomic level. Dominance, similarity index and EPT taxa number was used for numerical analysis and determination of habitat quality and Belgian Biotic Index was used in biological water quality assessment.

No	Location	Running water	Altitude (m)	Bottom structure (%)			Vegetation	Width (m)	Stream region
				stone	gravel	sand			
1	Bolu	Aladağ	1351	10	20	70	xx	1	epirhithron
2	Bolu	Aladağ	1352	60	30	10	xx	3	epirhithron
3	Bolu	Aladağ	1467	70	20	10	xx	2	epirhithron
4	Bolu	Abant	850		80	20	x	3	metarhithron
5	Bolu	Devrek	1273	45	50	5	xx	0,7	epirhithron
6	Düzce	Devrek	1418		60	40	xx	3	epirhithron
7	Düzce	Devrek	1418		60	40	xx	3	epirhithron
8	Düzce	Bıçkı	756	10	70	20	x	4	epirhithron
9	Karabük	Soğanlı	901		50	50	xx	1,5	krenon
10	Kastamonu	Gökırmak	914		10	90	x	10	epirhithron
11	Kastamonu	Ezine	55		80	20	x	10	hyporhithron
12	Kastamonu	Ezine	108		80	20	xx	4	epirhithron
13	Kastamonu	Ezine	108		80	20	xx		pool
14	Sinop	Kabalı	237		60	40	xx	10	epirhithron
15	Sinop	Güzelçay	216		80	20	xx	20	hyporhithron

Table 1. Physical characteristics of sampling sites.

Dominance

The dominant species in each sites were used to determine habitat quality (Krebs, 1989). Dominance was calculated using the number of individual of one taxon and all taxa at one site.

$$D = N_a / N_n \times 100$$

D : Dominance value

N_a : Number of individuals of taxon A

N_n : Number of individuals of all taxa

Quotient of Community Similarity

The Sorensen similarity index was used to classify species between samples and sites (Hellawell, 1989). The values of this index can vary between 0 and 1.

$$q = 2c / a + b$$

c : the number of taxa in both samples

a : the number of taxa in the first sample

b : number of different taxa in second sample from the first sample

Results

Physico-Chemical Characteristics

Physico chemical characteristics of sites were given Fig. 3. According to this figure, temperature showed differences related with season and altitude. The highest temperature was 11.9°C at site 9, the lowest temperature was 24.6°C at site 15.

The highest dissolved oxygen (9.72 mg/l) and percentage of dissolved oxygen (112%) values were measured at site 11. The lowest dissolved oxygen (2.16 mg/l) and percentage of dissolved oxygen (25.8%) value was lower at site 13 due to sampling from pool habitat near the running water. Oxygen saturation was quite low in this site.

pH was lower at site 9 (7.05), higher at site 11 (8.46). pH value range for organisms is 6.0–8.5 (Goldman and Horn, 1983). According to results of this study, pH values were appropriate for organisms. Salinity of sites was changed between 0.1 and 0.3 ppt.

The highest conductivity was 50.23 $\mu\text{S}/\text{cm}$ at site 9, the lowest conductivity was 365.5 $\mu\text{S}/\text{cm}$ at site 10. The conductivity decreased at site 9 because this site was in krenon which shows ground water characteristic.

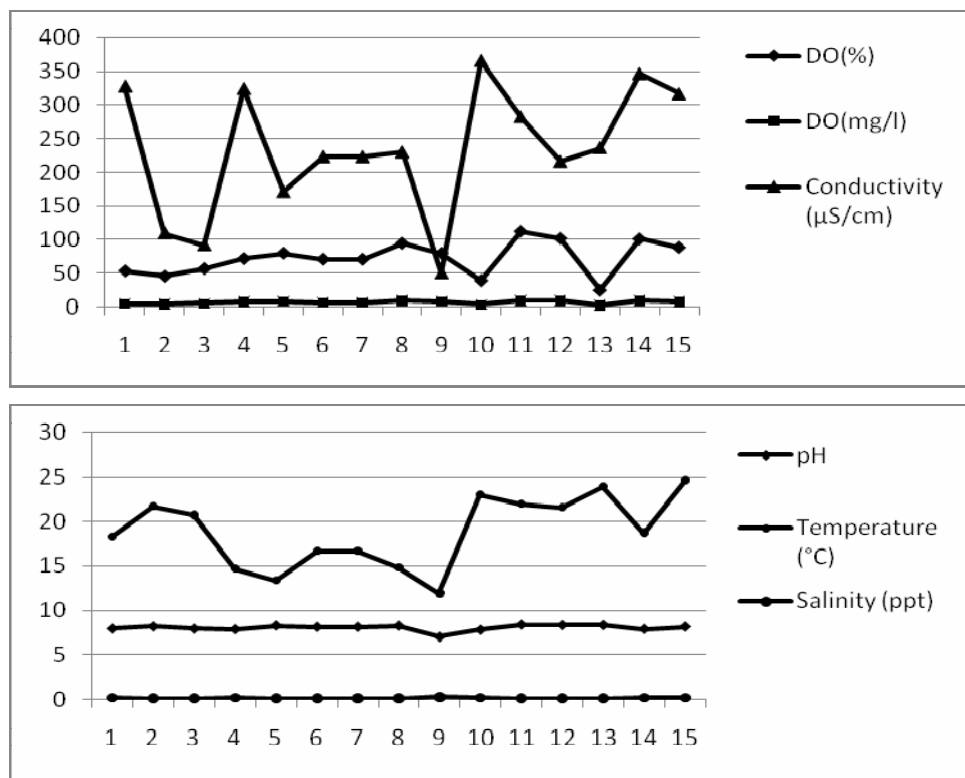


Figure 3. Physico-chemical results of sampling sites

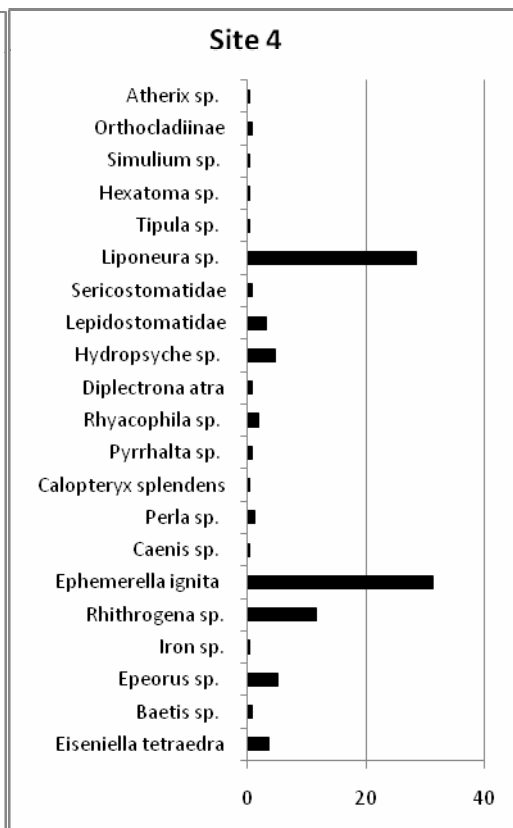
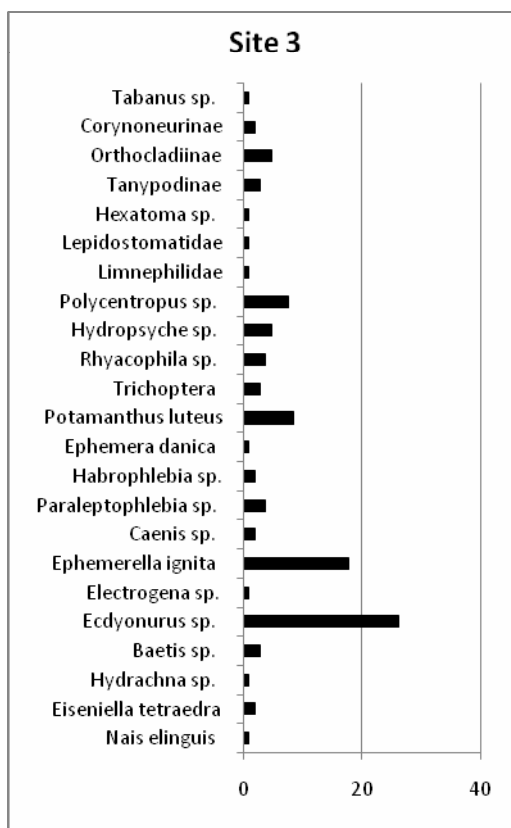
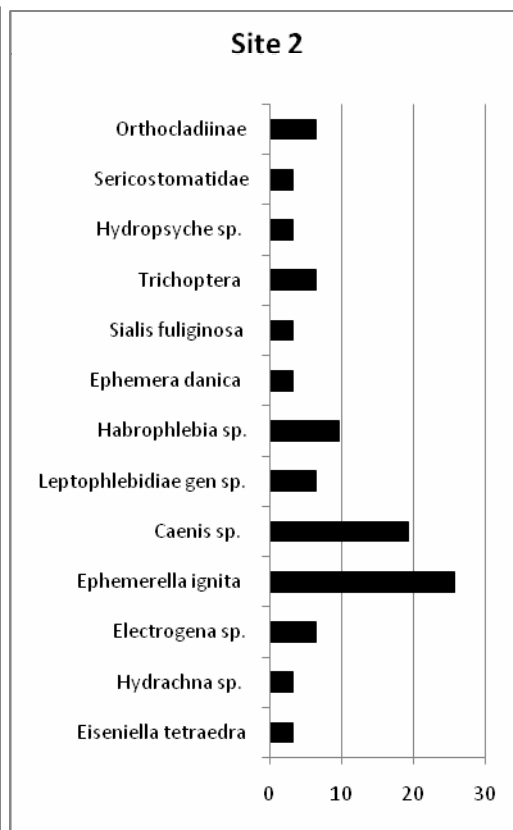
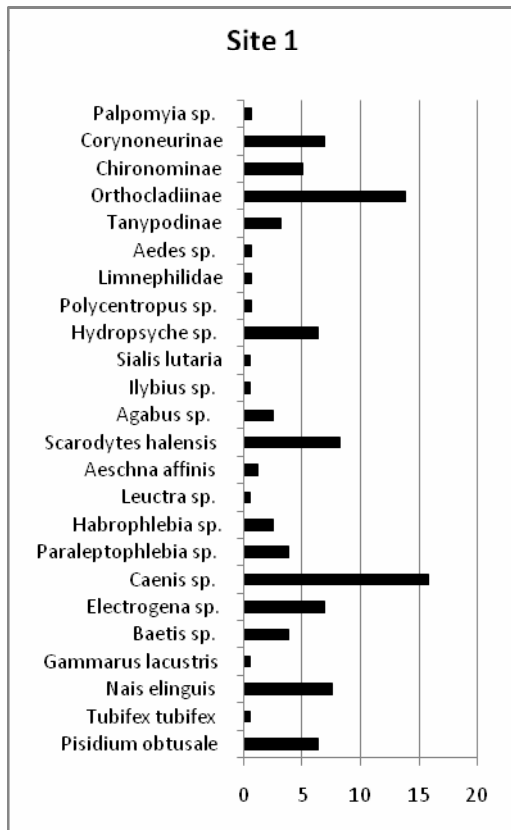
Macroinvertebrates

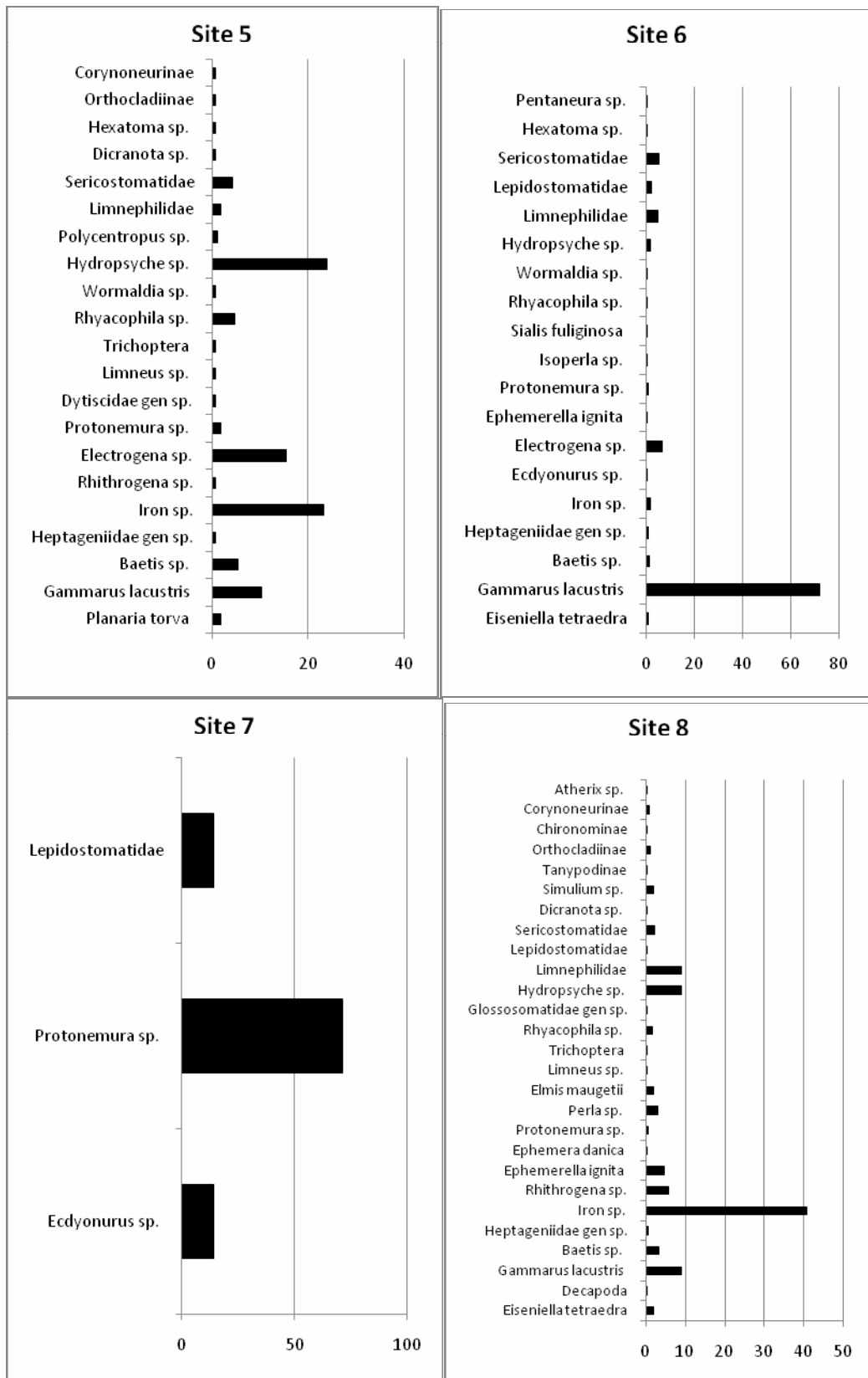
A total of 7106 individuals was collected and 98 taxa was identified (Table 2) The 16 taxa were from Platyhelminthes, Gastropoda, Bivalvia, Oligochaeta, Arachnida, Malacostraca and 82 taxa were from Insecta. The 16 taxa of Ephemeroptera, 4 taxa of Plecoptera, 4 taxa of Odonata, 5 taxa of Hemiptera, 14 taxa of Coleoptera, 2 taxa of Megaloptera, 15 taxa of Trichoptera, 2 taxa of Lepidoptera ve 20 taxa of Diptera were identified from Insecta.

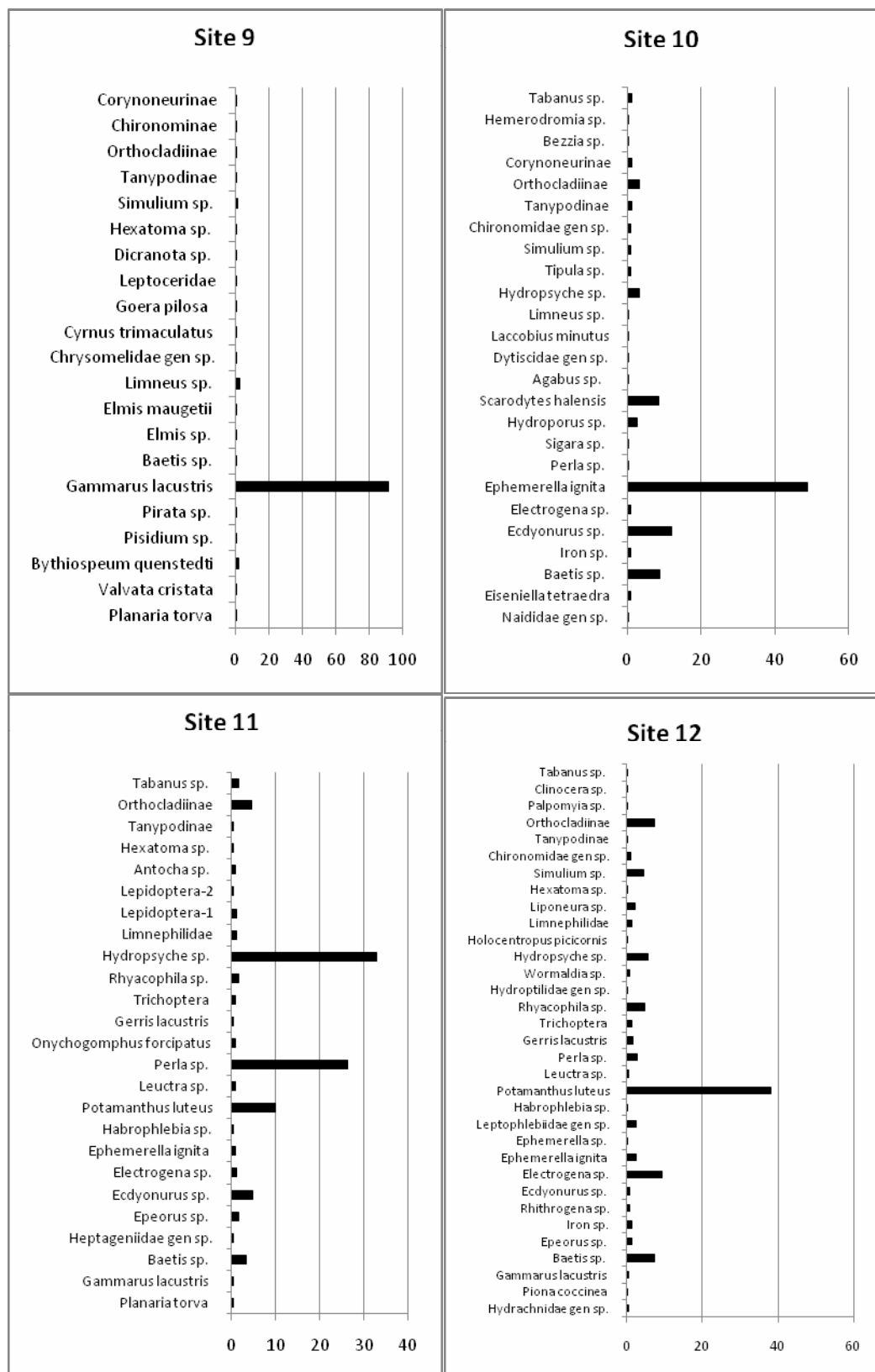
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>Planaria torva</i> Müller, 1774					*				*		*				
<i>Valvata cristata</i> O.F. Müller, 1774									*						
<i>Bythiospeum quenstedti</i> Wiedersheim, 1873									*						
<i>Pisidium</i> sp. C. Pfeiffer, 1821									*						
<i>Pisidium obtusale</i> Lamarck, 1818	*														
<i>Tubifex tubifex</i> Müller, 1774	*														
Naididae gen sp.										*			*		

<i>Nais elinguis</i> Müller, 1774	*		*															
<i>Pristina</i> sp. Ehrenberg, 1828												*						
<i>Eiseniella tetraedra</i> Savigny, 1826		*	*	*		*		*		*								
Hydrachnidae gen sp.												*						
<i>Hydrachna</i> sp. O. F. Müller, 1776		*	*															
<i>Piona coccinea</i> Koch, 1836												*						
<i>Pirata</i> sp. Sundevall, 1833									*									*
Decapoda Latreille, 1802								*										
<i>Gammarus lacustris</i> Sars, 1863	*				*	*		*	*		*	*	*	*	*	*	*	*
<i>Baetis</i> sp. Leach, 1815	*		*	*	*	*		*	*	*	*	*	*	*	*	*	*	*
<i>Oligoneuriella</i> sp. Ulmer, 1924																		*
Heptageniidae gen sp.					*	*		*			*							*
<i>Epeorus</i> sp. Eaton, 1881				*							*	*			*	*		*
<i>Iron</i> sp. Eaton, 1881				*	*	*		*		*		*						
<i>Rhithrogena</i> sp. Eaton, 1881				*	*			*				*					*	*
<i>Ecdyonurus</i> sp. Eaton, 1870			*		*	*		*	*	*	*	*			*	*		*
<i>Electrogena</i> sp. Zurwerra & Tomka, 1985	*	*	*		*	*		*	*	*	*	*	*	*	*	*	*	*
<i>Ephemerella</i> sp. Walsh, 1863												*						
<i>Ephemerella ignita</i> Poda, 1761		*	*	*		*		*		*	*	*	*	*	*	*	*	*
<i>Caenis</i> sp. Stephens, 1835	*	*	*	*														
Leptophlebiidae gen sp.		*										*	*	*				
<i>Paraleptophlebia</i> sp. Lestage, 1917	*		*															*
<i>Habrophlebia</i> sp. Eaton, 1881	*	*	*								*	*					*	
<i>Ephemera danica</i> Müller, 1764		*	*					*										
<i>Potamanthus luteus</i> Linnaeus, 1767			*								*	*	*					
<i>Protonemura</i> sp. Kempny, 1898					*	*	*	*										
<i>Leuctra</i> sp. Stephens, 1836	*										*	*			*			
<i>Isoperla</i> sp. Banks, 1906						*												
<i>Perla</i> sp. Geoffroy, 1762				*				*	*	*	*	*			*	*		*
<i>Epallage fatime</i> Charpentier, 1840																		*
<i>Calopteryx splendens</i> Haris, 1782				*														
<i>Aeschna affinis</i> Vander Linden, 1820	*																	
<i>Onychogomphus forcipatus</i> Linnaeus,											*				*	*		*

Ephemerella ignita was dominant at site 2 (25.8%). Other dominant taxon was *Caenis* sp. with 19.3%. *Ecdyonurus* sp. (26.16%) and *Ephemerella ignita* (17.75%) were the most dominant taxa at site 3. *Ephemerella ignita* (31.45%) was dominant at site 4. *Liponeura* sp. (28.6%) and *Rhithrogena* sp. (11.7%) were other dominant taxa at site 4. *Hydropsyche* sp. (23.9%), *Iron* sp. (23.3%) and *Electrogena* sp. (15.5%) were dominant at site 5. *Gammarus lacustris* (71.8%) at site 6 and *Protonemura* sp. (71.4%) at site 7 were the most dominant taxa. *Iron* sp. (40.85%) was dominant at site 8. Other dominant taxa were Limnephilidae (9.1%), *Gammarus lacustris* (8.84%) and *Hydropsyche* sp. (8.84%). At site 9 the most dominant taxon was *Gammarus lacustris* (91.5%). *Ephemerella ignita* (48.9%), *Ecdyonurus* sp. (12.3%) and *Baetis* sp. (8.78%) were dominant taxa at site 10. The various taxa had different dominance value at site 11. These taxa were *Hydropsyche* sp. (32.9%), *Perla* sp. (26.3%), *Potamanthus luteus* (10.08%), *Ecdyonurus* sp. (4.8%) and Orthocladiinae (4.6%). *Potamanthus luteus* (38.18%) was dominant at site 12. *Electrogena* sp. (36.2%), *Potamanthus luteus* (13.8%), *Gammarus lacustris* (12.06%) and Naididae (8.62%) were dominant taxa at site 13. The various taxa had different dominance value at site 14. These taxa were *Epeorus* sp. (22.8%), *Hydropsyche* sp. (14.9%), *Ecdyonurus* sp. (12.2%), *Baetis* sp. (11.7%), *Rhyacophila* sp. (6.11%) and *Electrogena* sp. (5.58%). At site 15 *Hydropsyche* sp. (59.2%) was dominant. *Ecdyonurus* sp. (8.46%) and *Perla* sp. (8.46%) were other dominant taxa. The similarity between sampling sites was calculated with Sorensen similarity index. The highest similarity between sites 11 and 12 which were chosen on the same running water was 0.97. Additionally the similarity value was 0.8 between sites 12 and 14; 0.82 between sites 3 and 11; 0.83 between sites 11 and 14; 0.85 between sites 5 and 6; 0.9 between sites 5 and 8 (Table 3).







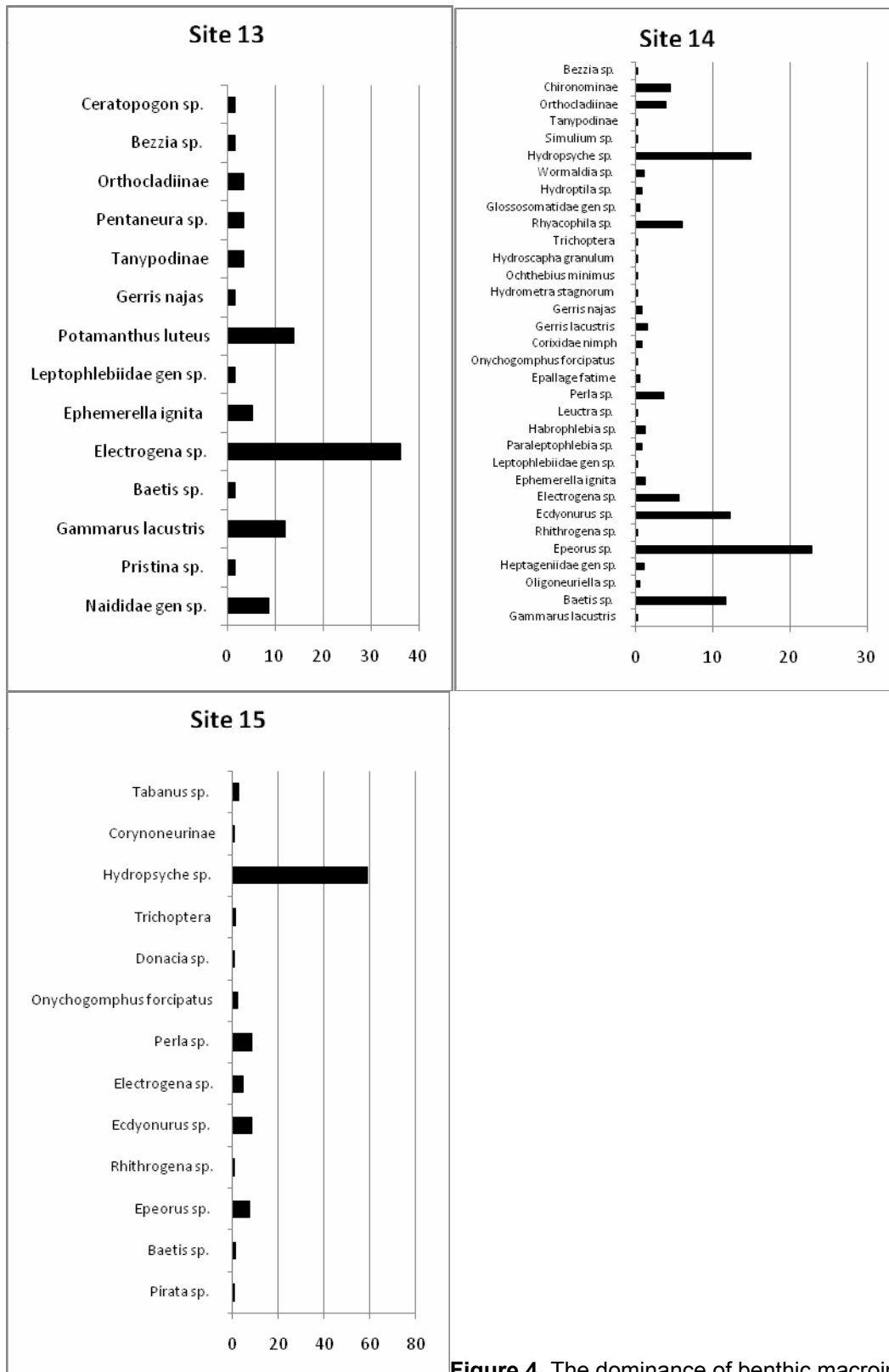


Figure 4. The dominance of benthic macroinvertebrates.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	0,31	0,61	0,19	0,43	0,26	0	0,37	0,3	0,38	0,45	0,42	0,3	0,42	0,24

2		1	0,77	0,42	0,34	0,46	0	0,35	0,06	0,29	0,375	0,35	0,34	0,35	0,26
3			1	0,51	0,58	0,625	0,16	0,5	0,25	0,51	0,82	0,63	0,38	0,48	0,48
4				1	0,47	0,58	0,087	0,74	0,21	0,47	0,42	0,57	0,18	0,4	0,26
5					1	0,85	0,087	0,9	0,47	0,41	0,62	0,57	0,25	0,4	0,42
6						1	0,31	0,7	0,162	0,36	0,58	0,53	0,35	0,41	0,28
7							1	0,14	0	0,07	0,07	0,057	0	0,057	0,13
8								1	0,52	0,52	0,47	0,55	0,27	0,6	0,35
9									1	0,29	0,3	0,25	0,19	0,25	0,125
10										1	0,42	0,51	0,42	0,4	0,43
11											1	0,97	0,36	0,83	0,53
12												1	0,41	0,8	0,48
13													1	0,47	0,16
14														1	0,48
15															1

Table 3. The Sorensen similarity index values.

Biotic Index and EPT taxa number

Belgian Biotic Index (BBI) was applied to running waters in western Black Sea Region (Table 4). This index is one of the most common index using in biomonitoring studies. This index applied by Kazancı et al. (1993) for the first time to running waters in Köyceğiz-Dalyan protected area in south eastern Turkey. The results of the BBI and the physico-chemical characteristics of sites were concordant in previous applications (Kazancı, 1993; Girgin and Kazancı, 1994; Kazancı et al. 1997; Kazancı and Dögel, 2000; Dögel and Kazancı, 2004; Kazancı et al. 2003). According to BBI values, sites 1, 2, 4, 5, 7 and 10 were class III. This class indicates moderately polluted water and a critical situation (Kazancı and Dögel, 2000). Sites 6 and 15 were detected in class II. This level indicates slightly polluted environment. Sites 3, 8, 9, 11, 12, 13, and 14 were class I. This class indicates unpolluted waters (Streble and Krauter, 1988).

Ephemeroptera, Plecoptera and Trichoptera (EPT) are most common benthic organisms in running waters. These taxa contains sensitive species to environmental changes (Plafkin et al. 1989). EPT taxa numbers were numerically calculated in this research (Table 4). The highest EPT taxa number was counted as 20 taxa at site 12 and the lowest EPT taxa number was counted as three taxa at site 7.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
BBI Quality Class	III	III	I	III	III	II	III	I	I	III	I	I	I	I	II
EPT Taxa Number	9	9	15	12	13	14	3	15	4	7	14	20	5	19	8

Table 4. BBI quality class and EPT taxa number of sampling sites.

Discussion

In this research, a part of benthic macroinvertebrate fauna of western Black Sea Region was determined. Benthic macroinvertebrate samples were collected and identified from 15 sampling sites by considering physical and chemical characteristics of various running waters. Belgian Biotic Index

and numerical analysis were carried out for determination of habitat quality.

Physico-chemical characteristics were measured at each site. pH values were appropriate for organisms recorded at every sites in study area. Dissolved oxygen values are important for pollution level, organic substance concentration and habitat quality (Wetzel, 1983). Sites 8, 11, 12 and 14 with high oxygen values were also found class I which indicates unpolluted or slightly polluted waters. An increase in conductivity also indicates existence of pollutants besides ions derived from geological structure (MacDonald et al. 1991). Decomposition in water quality was found at sites 1, 4, 6, 7, 10 and 13 with high conductivity.

The results of biotic index and EPT index of sites were concordant (Table 4). In sites 3, 8, 12 and 14, EPT taxa number was moderately high and biotic index values were class I.

Streble and Krauter (1988) was used for saprobic value of all taxa and Moog et al. (1997), Kazancı (2001) were used for saprobic value of *Electrogena*. Species which had high dominance in all sampling sites were generally *Ephemerella ignita*, *Iron*, *Gammarus lacustris*, *Ecdyonurus*, *Hydropsyche*, *Potamanthus luteus*, *Electrogena* and *Baetis*. Orthocladiinae, Corynoneurinae, *Caenis*, *Nais elinguis*, *Liponeura*, *Perla* and *Epeorus* were other dominant taxa (Fig. 4). Stoneflies, mayflies and caddisflies are generally intolerant of organic pollution. However, *Cheumatopsyche* and *Hydropsyche* have been found in moderately polluted water in caddisflies (Hynes, 1960).

Saprobically *Iron* and *Perla* prefers unpolluted or slightly polluted waters. *Ephemerella ignita*, *Baetis*, *Hydropsyche* and *Ecdyonurus* are tolerant of moderate pollution and they can live in waters changed from unpolluted to moderately polluted. *Potamanthus luteus*, *Electrogena*, Orthocladiinae, Corynoneurinae, *Caenis*, *Nais elinguis*, *Liponeura* and *Epeorus* are found slightly or moderately polluted waters.

At site 1 biotic index value indicated class III. EPT taxa number (9) and dominant species (*Caenis*, Orthocladiinae, *Nais elinguis*, Corynoneurinae, *Electrogena*) were reflected moderately polluted water. According to biotic index value, class III which reflects moderately polluted level was found at site 2. *Ephemerella ignita* and *Caenis*, dominant taxa were tolerant to pollution and EPT taxa number (9) also assisted these assessments.

At site 3, biotic index and EPT taxa number (15) showed class I characteristics. Dominant taxa of this site, *Ecdyonurus* and *Ephemerella ignita* are found both unpolluted and moderately polluted waters.

EPT taxa number (12 at site 4 and 13 at site 5), class III and dominant species (*Ephemerella ignita*, *Liponeura*, *Hydropsyche*, *Iron*) reflected slightly or moderately polluted waters at sites 4 and 5.

Biotic index value, class II and EPT taxa number (14) showed slight pollution at site 6. *Gammarus lacustris* was the dominant taxon (90%).

Biotic index value indicated class III at site 7. This site had the least individual number and EPT taxa (3) among all sampling sites.

According to biotic index value and EPT taxa (15), class I was found at site 8. This was compatible with dominant taxon (*Iron*) of site 8 which prefers unpolluted or slightly polluted waters.

Unpolluted or slightly polluted water was detected at site 9 with biotic index value. This site had lowest conductivity and temperature because of sampling from the source. The water temperature was lower than other sites (11.9°C) *Gammarus lacustris* was dominant species which prefers unpolluted or slightly polluted and cool waters. The lowest conductivity (50.23 µS/cm) was recorded in this site.

Site 10 was moderately polluted according to biotic index (class III), EPT taxa number (7) and dominant species (*Ephemerella ignita*, *Ecdyonurus* and *Baetis*).

Sites 11 and 12 were in class I which indicated unpolluted or slightly polluted environment according to biotic index, EPT taxa number (14 at site 11 and 20 at site 12) and dissolved oxygen values (9.72 mg/l at site 11 and 8.92 mg/l at site 12). Additionally the higher similarity (0.97) was also found between these two sites on the same running water.

Site 13 was stagnant and separated part on running water. The lowest dissolved oxygen values (2.16 mg/l) showed polluted level in this site. Water temperature was high (24°C) due to stagnant water.

Biotic index values showed class I at site 14. Additionally, EPT taxa number (19) was high than other sites and indicates unpolluted or slightly polluted water. The dominant taxa were *Epeorus*, *Hydropsyche* and *Ecdyonurus*. These taxa can live in slightly polluted waters.

Site 15 was class II according to biotic index value, EPT taxa number (8) and dominant taxon *Hydropsyche* showed slightly or moderately polluted waters.

Conclusion

Results are important to show how can environmental changes affect distribution of benthic macroinvertebrates. This research is a basic study for providing comparative data to use biological and physicochemical parameters in long-term monitoring studies in western Black Sea Region.

According to the results of this research *Baetis* sp., *Ephemerella ignita* and *Hydropsyche* sp. are species living in moderately polluted waters. *Iron* sp., *Rhithrogena* sp., *Perla* sp., *Elmis maugetii*, *Protonemura* sp., *Liponeura* sp. indicated unpolluted or slightly polluted sites (class I) in study area.

According to physico-chemical variables, BBI and EPT taxa number, sampling sites were unpolluted, slightly polluted and moderately polluted in this research. It has been seen that benthic macroinvertebrate fauna in running waters are related with water quality. These results have been shown that running waters in this region is face to face with habitat degradation. Consequently, biomonitoring of running waters, eliminating pollution sources and sustaining conservation and management procedures are necessary for protection of high water quality of running waters.

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