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Araştırma Makalesi / Research Paper**Diversity and Species Composition of the Macroenthic Invertebrates in Sürgü Stream (Malatya, Turkey)**Serap KOŞALŞAHİN¹, Melek ZEYBEK^{2*}¹Istanbul University, Faculty of Fisheries, İstanbul²Süleyman Demirel University, Faculty of Arts and Sciences, Isparta

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ABSTRACT

The study was carried out on Sürgü Stream, located in Malatya Province (Turkey), and aimed to determine the diversity and species composition of macroenthic invertebrates. Six stations were determined on the stream and macroenthic invertebrates were taken seasonally. As a result, 34 taxa belonging to five classes were detected; one of which belongs to Hirudinea, one of which belong to Arachnida, three to Gastropoda, five to Malacostraca and 24 to Insecta classes. Insecta was the most dominant group among the determined taxa. The Shannon Weaver Diversity Index and the Simpson Index showed that the lowest species diversity was observed at the third station while the highest species diversity was found at the second station. Also, UPGMA algorithm was used to show possible clustering relationships among the seven stations based on organisms. According to UPGMA analysis, the highest similarity value was observed between the first and second stations (87%), while the lowest similarity value was found between the second and fourth stations (13%). To date, there is no study on the determination of macroenthic invertebrate fauna of Sürgü Stream. Therefore, all the identified taxa have been recorded for the first time for the study area.

Keywords: Macroenthic invertebrates, Species diversity, Sürgü Stream, Malatya**Sürgü Çayı (Malatya, Türkiye)'nda Makroentik Omurgasızların Tür Kompozisyonu ve Çeşitliliği****ÖZ**

Bu çalışmada Malatya İli'nde (Türkiye) yer alan Sürgü Çayı'nın makroentik omurgasızlarının tür kompozisyonunun ve çeşitliliğinin belirlenmesi amaçlanmıştır. Altı istasyon belirlenmiş ve örnekler mevsimsel olarak alınmıştır. Sonuç olarak beş sınıfa ait; Hirudinea ve Arachnida sınıflarından bir, Gastropoda'dan üç, Malacostraca'dan beş ve Insecta sınıflarından 24 olmak üzere; 34 takson tespit edilmiştir. Belirlenen taksonlar arasında en baskın grup Insecta olmuştur. Shannon Weaver çeşitlilik indeksi ve Simpson indeksine göre en düşük çeşitlilik üçüncü istasyonda, en yüksek çeşitlilik değeri ikinci istasyonda bulunmuştur. Ayrıca, organizmalara dayalı olarak yedi istasyon arasındaki kümeleme ilişkilerini göstermek için UPGMA algoritması kullanılmış, buna göre, en yüksek benzerlik değeri birinci ve ikinci istasyonlar arasında (%87), en düşük benzerlik değeri ise ikinci ve dördüncü istasyonlar arasında (%13) bulunmuştur. Bugüne kadar Sürgü Çayı'nın makroentik omurgasız faunasının belirlenmesine yönelik bir çalışma yoktur. Bu nedenle, belirlenen tüm taksonlar çalışma alanı için ilk kez kaydedilmiştir.

Anahtar Kelimeler: Makroentik omurgasızlar, Tür Çeşitliliği, Sürgü Çayı, Malatya

INTRODUCTION

Freshwater ecosystems have important multi-usage components, such as sources of drinking water, irrigation, fishery and energy production. Nevertheless, streams and lakes are among the most threatened ecosystems in the world (Malmqvist and Rundle, 2002). It is important to understand the consequences of human perturbations on these ecosystems to maintain restore their integrity (Meybeck, 2003). Macroenthic invertebrates have an important role in the biomonitoring studies carried out for this purpose (Rosenberg and Resh, 1993).

Biological monitoring of freshwater ecosystems began more than a century ago and the different taxonomic groups assemblages (e.g. bacteria, algae, and fish) have used for determining of water quality (Hellawell, 1986; Metcalfe, 1989; Rosenberg and Resh, 1993; Dolédec and Statzner 2010). Macroenthic invertebrates are one of the most preferred groups in these studies (Azrina et al., 2006; Johnson and Ringler, 2014; Herman and Nejadhashemi, 2015). Because, the life cycles of this group are long enough to understand what the differences are in their habitats before and after the pollution, they have limited habitat, they are sensitive to pollution by altering their community composition (Rosenberg and Resh 1993; Lunde and Resh, 2012).

The studies of freshwater macroenthic invertebrates as biological monitoring techniques have been widely reported and described by the various researchers in Turkey (Kazancı and Dügel 2000; Duran et al., 2003; Balık et al., 2006; Kalyoncu and Zeybek, 2009; Türkmen and Kazancı 2010; Yıldız et al., 2010; Kalyoncu and Zeybek 2011; Zeybek et al., 2012; Kazancı et al. 2013; Zeybek et al., 2014; Yıldız et al., 2015).

In order to be able to carry out biomonitoring studies using macroenthic invertebrates, it is important to first determine the macroenthic fauna of study area. Although the important of them in freshwater ecosystems has been reported, and there has been no research about macroenthic fauna of Sürgü Stream. It is hoped that the results of this study will provide basic information for biomonitoring studies to be carried out in this stream.

MATERIAL AND METHODS

Malatya is located at the upper parts of Fırat River Basin in Eastern Anatolia. The present study was carried out on Sürgü Stream in Malatya province (Turkey) between April 2014-February 2015. The length of this stream is approximately 30 km. The stream is an important water source for Malatya and is mainly used for irrigation. It is one of the most important tributaries of the Göksu River. Six stations were defined at the stream and samplings were performed seasonally. Totally, 24 samples had been taken per site/single sampling from six stations at four seasons (Figure 1).

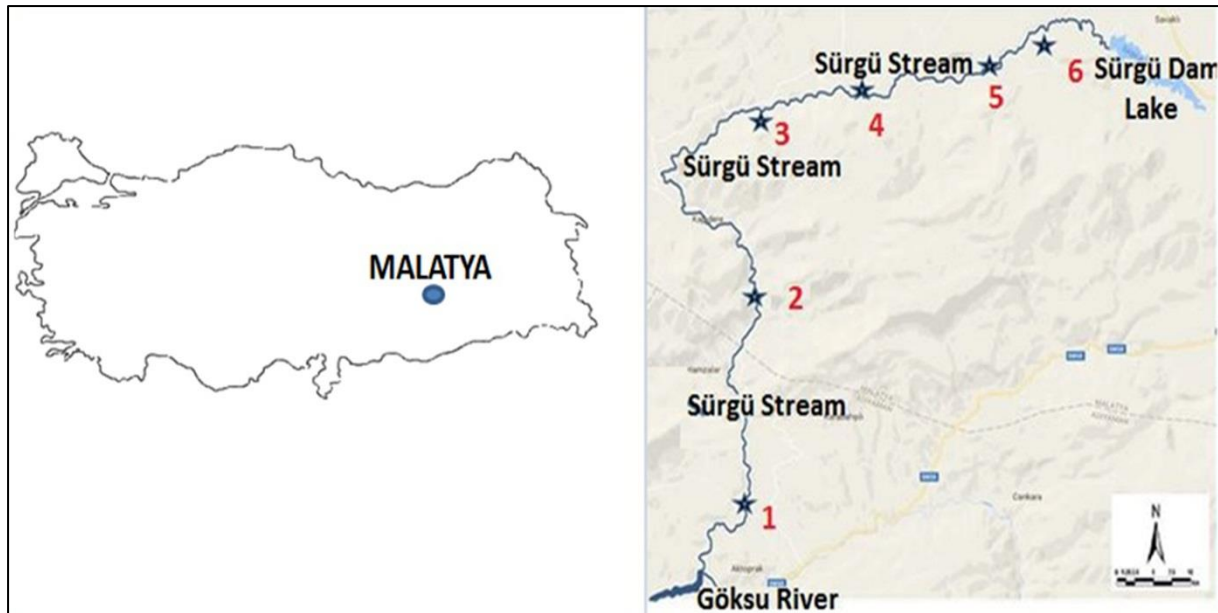


Figure 1. Study area and stations on the Sürgü Stream

Some physical properties of the selected stations are shown in the Table 1.

Table 1. Some physical characters of the stations

Station	Substrate	Macrophytes	Depth(m)
1	gizzard	*	0,5
2	stony+muddy	*	0,7
3	gizzard		0,6
4	gizzard+muddy	*	0,65
5	sandy+gizzard	*	0,5
6	stony+muddy	*	0,75

Macroinvertebrates were sampled from each station by using a standart kick net (500 µm mesh sized). The samples were taken from the various substrate types (e.g. silt, gravel, sand) present at the stations. At some stations, where large stones present, stones were firstly picked out from the locality and were washed into the net in order to remove pupae and other attached individuals. Each sampling took 3 minutes. The collected material was fixed in formaldehyde (4%) in the field and then kept in 80% ethyl alcohol. They were sorted in the laboratory and identified to the lowest possible taxonomic level (genus or species) under a stereomicroscope. The unweighted pair group method with arithmetic mean (UPGMA) algorithm was used to define for possible clustering relationships among the stations in terms of macroinvertebrates. Also, Shannon Weaver Diversity Index (1963) and Simpson (1949) indices were

applied to determine the species diversity of the stations. UPGMA and was performed based on macroinvertebrates by using MVSP version 3.1 (Kovach, 1998). The relative percentage of occurrence was calculated for each species by using the simple formula $N_i/N_t \times 100$ (N_i = individuals of species i, N_t = total number of collected species).

RESULTS AND DISCUSSION

As a result of the study, 1539 individuals and 34 taxa belonging to five classes were determined. The maximum number of individuals was observed at the station 3 (548 individuals) while the fewest at the station 6 (59 individuals). The determined species were belong to Hirudinea (1 taxon), Arachnida (1 taxon), Gastropoda (3 taxa), Malacostraca (5 taxa), Insecta (25 taxa). Insecta was the most dominant group among the determined taxa. This class was also found as the dominant taxa in different streams in Turkey several times (Duran, 2006; Zeybek et al., 2014; Yorulmaz et al., 2015; Zeybek, 2017). Distributions and relative percentage of occurrence (%), along with a list of the recorded macrozoobenthic invertebrates, were showed in Table 1. The relative percentages of occurrence (%) of the determined species were differed from each other. For instance, *Ancylus fluviatilis* was the most dominant species (19.30%) at the station 1; *Baetis rhodani* (16.53%) at the station 2; *Agapetus fuscipes* (70.8%) at the station 3; *Gammarus* sp. (32.81 %) at the station 4; *Hydropsyche instabilis* (24.59 %) at the station 5 and *Sericostoma personatum* (28.81 %) at the station 6 (Table 2).

Table 2. Distributions and relative occurrence (%) of macroinvertebrates at the stations

	Sta 1.	Sta 2.	Sta 3.	Sta 4.	Sta 5.	Sta 6.
MOLLUSCA						
Gastropoda						
<i>Acroloxus lacustris</i> (Linnaeus, 1758)	7.51	5.79	-	-	-	-
<i>Ancylus fluviatilis</i> O. F. Müller, 1774	19.30	10.74	-	-	-	-
<i>Theodoxus anatolicus</i> (Récluz, 1844)	12.87	21.49	-	-	-	-
Malacostraca						
<i>Gammarus birsteini</i> Karaman & Pinkster, 1977	-	-	3.28	2.34	-	-
<i>G. kischineffensis</i> Schellenberg, 1937	-	-	2.19	10.94	-	-
<i>G. pseudosyriacus</i> Karaman & Pinkster, 1977	-	-	6.93	16.41	-	10.17
<i>G. pulex</i> (Linnaeus, 1758)	-	-	2.92	8.20	-	5.08
<i>Gammarus</i> sp.	-	-	1.09	32.81	-	5.08
ARTHROPODA						
Arachnida						
<i>Atractides walteri</i> (Viets, 1925)	-	-	-	-	6.56	5.08
Insecta						

Table 2. Distributions and relative occurrence (%) of macrobenthic invertebrates at the stations (continued...)

	Sta 1.	Sta 2.	Sta 3.	Sta 4.	Sta 5.	Sta 6.
Ephemeroptera						
<i>Baetis buceratus</i> Eaton, 1870	2.14	2.48	-	-	1.64	-
<i>B. muticus</i> (Linnaeus, 1758)	2.14	4.96	0.73	0.78	-	-
<i>B. rhodani</i> (Pictet, 1845)	18.23	16.53	3.65	-	-	-
<i>B. scambus</i> Eaton, 1870	1.07	2.48	-	-	-	-
<i>B. vernus</i> Curtis, 1834	6.43	4.96	1.09	-	-	-
<i>Nigrobaetis digitatus</i> (Bengtsson, 1912)	3.22	1.65	0.36	-	-	-
<i>Caenis horaria</i> (Linnaeus, 1758)	-	-	0.18	2.34	6.56	-
<i>C. macrura</i> Stephens, 1835	-	-	-	0.78	6.56	-
<i>C. pusilla</i> Navas, 1913	-	-	0.18	-	-	-
<i>Ephemerella danica</i> Müller, 1764	-	1.65	0.73	-	-	-
<i>E. vulgata</i> Linnaeus, 1758	0.80	2.89	0.36	-	-	-
Odonata						
<i>Aeshna</i> sp.	1.07	0.83	-	0.39		
Plecoptera						
<i>Leuctra hippopus</i> Kempny, 1899	1.07	0.83	-	-	-	-
<i>Leuctra</i> sp.	0.54	2.48	-	-	-	-
<i>Isoperla</i> sp.	1.07	3.31	-	-	-	-
Trichoptera						
<i>Agapetus fuscipes</i> Curtis, 1834	11.80	-	70.80	15.23	18.03	-
<i>Goera pilosa</i> (Fabricius, 1775)	3.22	-	-	3.91	-	-
<i>Hydropsyche fulvipes</i> Curtis, 1834	3.75	5.79	-	-	-	-
<i>H. instabilis</i> (Curtis, 1834)	-	-	-	4.30	24.59	25.44
<i>Polycentropus irroratus</i> Curtis, 1835	-	-	2.74	-	-	-
<i>Sericostoma personatum</i> (Kirby & Spence, 1826)	3.77	5.79	2.01	-	-	28.81
Coleoptera						
<i>Elmis maugetii</i> Latreille, 1798	-	1.24	0.76			
Diptera						
<i>Chaoborus</i> sp.	-	4.13	-	-	4.92	3.39
<i>Simulium</i> sp.	-	-	-	-	11.48	3.39
ANNELIDA						
Hirudinea						
<i>Helobdella stagnalis</i>	-	-	-	1.57	19.66	13.56
TOTAL	373	242	548	256	61	59

Considered determined species in general, there were species living in slightly or moderately polluted water at the first four stations. There was dominance of any species that indicates heavily polluted stream. It was found

species belong to Hirudinea class in both stations 5 and 6. However, the species belong to Trichoptera and Ephemeroptera orders and *Gammarus* were detected in the same stations too.

Gammarus species are found intensively in slightly polluted sections of the rivers (Meyer, 1987; Kalyoncu and Zeybek, 2009). Members of EPT are considered to be sensitive to environmental stress, thus their presence in high abundance at the upstream signified a relatively clean environment (Armitage et al., 1983). Therefore, EPT were found to be a potential bio-indicator for a clean ecosystem. According to Lenat (1988), EPT taxa are mostly found in clean waters and they give us information about the pollution status of the streams. The members of EPT include intolerant organisms and found in areas protecting its species richness (Armitage et al., 1983; Wahizatul et al., 2011).

The species belong to Ephemeroptera are sensitive to pollution; if the pollution increases, decline in number and diversity of these species is observed. They usually live in unpolluted habitats (Plafkin et al., 1989) and in much polluted habitats (alfa-mesosaprobic) no Ephemeroptera taxa can be observed (Moog et al., 1997; Bauernfeind et al., 1995).

Trichoptera larvae are affected by organic pollution and environmental changes. Therefore, they are important in biomonitoring studies (Dohet, 2002; Woodcock et al.,

2007; Zeybek and Koşal Şahin, 2016). In the present study, all the determined species of Gastropoda are commonly live clean water; they cannot survive in heavily polluted waters. Koşal Şahin and Zeybek (2016) reported that *Acroloxus lacustris* was showed positive correlation with DO values in Tunceli streams. *Theodoxus* species commonly lives in running waters of turbulent waters includes taxa living in springs, rivers, lakes and even in low-salinity waters and sometimes on the vegetation (Roth, 1987; Yıldırım, 2004; Yıldırım et al., 2006).

Percent similarities of each sampling station based on macrobenthic invertebrates in the study area were detected using UPGMA analysis. According to this analysis, stations 1 and 2 were the most similar to each other (87%) and stations 2 and 4 showed the lowest similarity (13%). The stations were clustered into two main groups. The first group contains two stations (1 and 2) while the second group consisted of two subgroups; stations 3 and 4 composed of the first subgroup and stations 5-6 the second one (Figure 2). It was observed that stations with similar ecological characteristics were located in the same group.

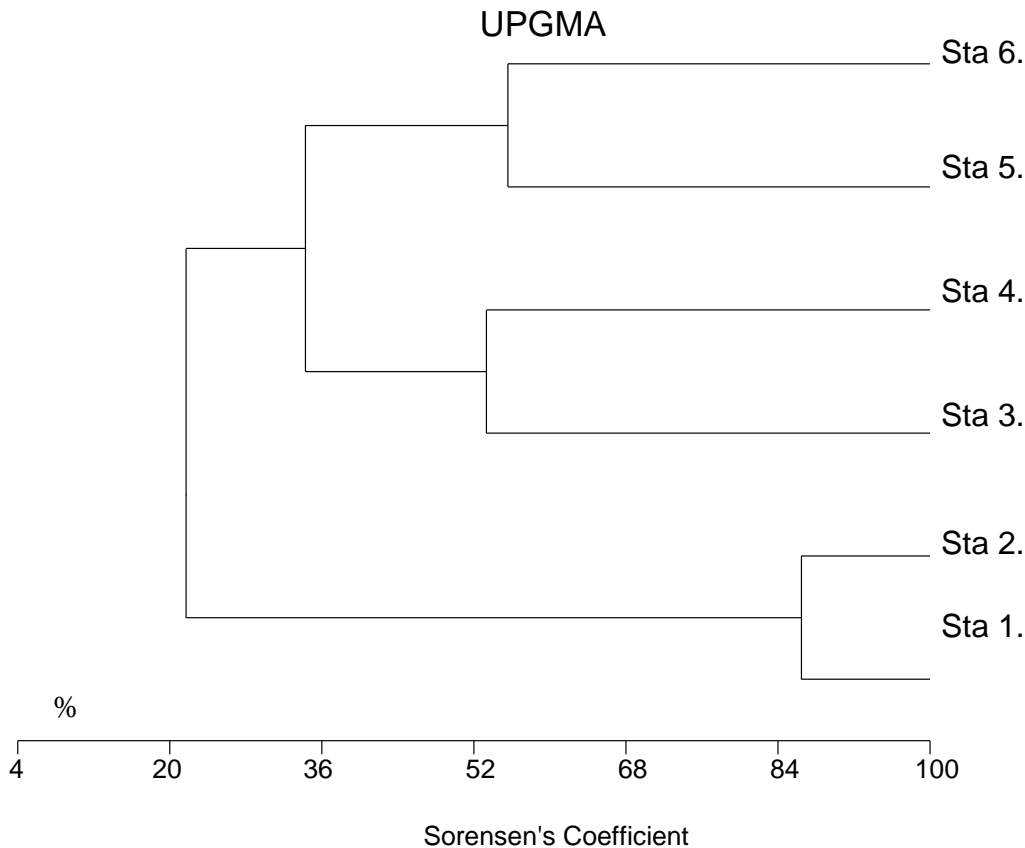


Figure 2. Cluster analysis dendrogram (UPGMA method) for stations based on macrobenthic invertebrates

Shannon Weaver, Simpson and Evenness indices were performed to detect the species diversity of the stations. According to these indices, the highest species diversity value was found at the second station while the lowest value at the third one (Table 3). In term of diversity, 5th and 6th stations had the lowest species diversity among

the stations. On the other hand, evenness values of the mentioned stations were detected to be high. Though the 3rd station represented 17 species, the diversity value was found to be low because of low value of evenness (Table 3).

Table 3. The values of Shannon Weaver and Simpson species diversity indices, and Evenness

Stations	Shannon Weaver		Simpson	
	Diversity value	Evenness	Diversity value	Evenness
Sta 1.	3.475	0.833	0.883	0.935
Sta 2.	3.681	0.866	0.894	0.943
Sta 3.	1.871	0.458	0.489	0.519
Sta 4.	2.88	0.778	0.819	0.887
Sta 5.	2.847	0.898	0.84	0.945
Sta 6.	2.732	0.862	0.814	0.915

Species diversity consists of two components: species richness and species evenness. Species richness is a simple count of species, whereas species evenness quantifies how equal the abundances of the species are (Hill, 1973; Tuomisto, 2010 a, b). The low evenness value indicated that there was no balance for distribution of their numbers of species and community was dominated by a taxon or some taxa (Magurran, 2004). Hence, it was also observed in 3rd station that *Agapetus fuscipes* was reached 70% of dominancy and the species diversity value of this station was determined to be low. According to Mason (2002), if Shannon- Weaver index value is between 1 and 3, the stream is moderately polluted. In this case, the pollution load of the first two stations is less than the other stations and the diversity values are higher than last four stations. They are moderately polluted.

CONCLUSION

Considering both the ecological characteristics and species diversity indices, it can be suggested that there is no heavy organic pollution in the stream.

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REFERENCES

- Armitage, P.D., Moss, D., Wright, J.F., Furse, M.T. (1983). The performance of a new biological water quality score system based on macroinvertebrates over a wide range of unpolluted running water sites. *Water Research* 17 (3): 333-347.
- Azrina, M.Z., Yap, C.K., Ismail, A.R., Ismail, A., Tan, S. G. (2006). Anthropogenic impacts on the distribution and biodiversity of benthic macroinvertebrates and water quality of the Langat River, Peninsular Malaysia. *Ecotoxicology and environmental safety*, 64 (3): 337-347.
- Balık, S., Ustaoglu, M. R., Özbek, M., Yıldız, S., Taşdemir, A., İlhan, A. (2006). Determination of pollution at lower basin of Küçük Menderes River (Selçuk, İzmir) by using macro benthic invertebrates, *Ege University Journal of Fisheries & Aquatic Science*, 23 (1-2): 61-65.
- Bauernfeind, E., Weichselbaumer, P., Moog, O. (1995). Ephemeroptera. In: *Fauna Aquatica Austriaca*. Moog, O. (Ed.), Teil 3, Lief. 1/1995, BMLF., Wasserkataster, Wien, 1-17.
- Dohet, A. (2002). Are caddisflies an ideal group for the biological assessment of water quality in streams. In: *Nova Sup-*

- plementa Entomologica, Proceedings of the 10th International Symposium on Trichoptera (pp. 507-520). Potsdam, Germany, Goecke & Evers., 664 pp.
- Dolédéc, S., Statzner, B. (2010). Responses of freshwater biota to human disturbances: contribution of J-NABS to developments in ecological integrity assessments. *Journal of the North American Benthological Society*, 29 (1): 286-311. <http://dx.doi.org/10.1899/08-090.1>
- Duran, M. (2006). Monitoring water quality using benthic macroinvertebrates and physicochemical parameters of Behzat Stream in Turkey. *Polish Journal of Environmental Studies*, 15(5): 709-717.
- Duran, M., Tüzen, M., Kayim, M. (2003). Exploration of biological richness and water quality of stream Kelkit, Tokat-Turkey. *Fresenius Environmental Bulletin*, 12 (4): 370-375.
- Hellawell, J.M. (1986). Biological indicators of freshwater pollution and environmental management. Elsevier Applied Science Publishers, London, UK.
- Herman, M. R., Nejadhashemi, A. P. (2015). A review of macroinvertebrate-and fish-based stream health indices. *Ecohydrology & Hydrobiology*, 15(2), 53-67. <http://dx.doi.org/10.1016/j.ecohyd.2015.04.001>
- Hill, M.O. (1973). Diversity and evenness: a unifying notation and its consequences. *Ecology*, 54 (2): 427-432.
- Johnson, S.L., Ringler, N.H. (2014). The response of fish and macroinvertebrate assemblages to multiple stressors: A comparative analysis of aquatic communities in a perturbed watershed (Onondaga Lake, NY). *Ecological Indicators*, 41: 198-208. <http://dx.doi.org/10.1016/j.ecolind.2014.02.006>
- Kalyoncu, H., Zeybek, M. (2009). Benthic Fauna of Ağlasun and Isparta Streams and Determination of Water Quality According to Physicochemical Parameters and Belgium Biotic Index. *Biyoloji Bilimleri Araştırma Dergisi*, 1 (3): 41-48.
- Kalyoncu, H., Zeybek, M. (2011). An application of different biotic and diversity indices for assessing water quality: A case study in the Rivers Çukurca and Isparta (Turkey). *African Journal of Agricultural Research*, 6 (1): 19-27. <http://dx.doi.org/10.5897/AJAR09>.
- Kazancı N, Türkmen G, Ekingen P, Başören Ö. (2013). Preparation of a biotic index (Yeşilirmak-BMW) for water quality monitoring of Yeşilirmak River (Turkey) by using benthic macroinvertebrates. *Review of Hydrobiology*, 6: 1-29.
- Kazancı, N., Dügel, M. (2000). An evaluation of the water quality of Yuvarlakçay Stream, in the Köyceğiz-Dalyan protected area, SW Turkey. *Turkish Journal of Zoology*, 24 (1): 69-80.
- Kovach, W.L. (1998). MVSP, A Multivariate Statistical Package for Windows, ver. 3.1. Kovach Computing Services, Pentraeth, UK.
- Lenat, D.R. (1988). Water quality assessment of streams using a qualitative collection method for benthic macroinvertebrates. *Journal of the North American Benthological Society*, 7 (3): 222-233.
- Lunde, K.B., Resh, V.H. (2012). Development and validation of a macroinvertebrate index of biotic integrity (IBI) for assessing urban impacts to Northern California freshwater wetlands. *Environmental monitoring and assessment*, 184 (6): 3653-3674.
- Magurran, A.E. (2004). Measuring biological diversity. Blackwell Science Publishing., UK.
- Malmqvist, B., Rundle, S. (2002). Threats to the running water ecosystems of the world. *Environmental conservation*, 29 (2): 134-153.
- Mason, C.F. (2002). *Biology of Freshwater Pollution*. Pearson Education, 4th ed. New York, USA.
- Metcalfe, J. L. (1989). Biological water quality assessment of running waters based on macroinvertebrate communities: history and present status in Europe. *Environmental pollution*, 60 (1-2): 101-139.
- Meybeck, M. (2003). Global analysis of river systems: from Earth system controls to Anthropocene syndromes. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 358 (1440): 1935-1955.
- Meyer, D. (1987). Makroskopisch-biologische Feldmethoden zur Wassergutebeurteilung von Fließgewässern, BUND Schriftenreihe, Hannover.
- Moog, O., Bauernfeind E. and Weicshelbaumer, P. (1997). Use of Ephemeroptera as saprobic indicators in Austria, In: *Ephemeroptera and Plecoptera: Biology-Ecology-Systematics*. Landolt, P. and M. Sartori (eds), MTL, Fribourg, 254-260.
- Plafkin, J. L., Barbour, M. T., Porter, K. D., Gross, S. K., Hughes, R.M. (1989). Rapid bioassessment protocols for use in streams and rivers: benthic macroinvertebrates and fish (EPA/444/4-89/001), Washington, DC: U.S. Environmental Protection Agency.
- Rosenberg, D.M., Resh, V.H. (1993). *Freshwater biomonitoring and benthic macroinvertebrates*. Chapman and Hall, New York.
- Roth, G. (1987). Data on the Distribution and Faunal History of the Genus *Theodoxus* in the Middle East (Gastropoda: Neritidae). Dr. Ludwig Reichert Verlag, 72-79.
- Şahin, S.K., Zeybek, M. (2016). Distribution of Mollusca Fauna in the Streams of Tunceli Province (East Anatolia, Turkey) and its Relationship with Some Physicochemical Parameters. *Turkish Journal of Fisheries and Aquatic Sciences*, 16: 187-195. http://dx.doi.org/10.4194/1303-2712-v16_1_19
- Shannon, C.E., Weaver, W. (1963). *The mathematical theory of Communication*. University of Illinois Press, Urbana.
- Simpson, E.H. (1949). Measurement of diversity. *Nature*, 163: 688.
- Tuomisto, H. (2010a). A diversity of beta diversities: straightening up a concept gone awry. Part 1. Defining beta diversity as a function of alpha and gamma diversity. *Ecography*, 33: 2-22. <http://dx.doi.org/10.1111/j.1600-0587.2009.05880.x>
- Tuomisto, H. (2010b). A consistent terminology for quantifying species diversity? Yes, it does exist. *Oecologia*, 4: 853-860. <http://dx.doi.org/10.1007/s00442-010-1812-0>
- Türkmen, G., Kazancı, N. (2010). Applications of various biodiversity indices to benthic macroinvertebrate assemblages in streams of a national park in Turkey, *Review of Hydrobiology*, 3: 111-125.
- Wahizatul, A.A., Long, S.H., Ahmad, A. (2011). Composition and distribution of aquatic insect communities in relation to water quality in two freshwater streams of Hulu Terengganu. *Journal of Sustainability Science and Management*, 6 (1): 148-155.
- Woodcock, T.S. Huryn, A.D. (2007). The response of macroinvertebrate production to a pollution gradient in a headwater stream. *Freshwater Biology*, 52 (1): 177-196. <http://dx.doi.org/10.1111/j.1365-2427.2006.01676.x>

- Yıldırım, M. Z. (2004). The Gastropods of Lake Eğirdir. *Turkish Journal of Zoology*, 28: 97-102.
- Yıldırım, M.Z., Koca, S.B., Kebapçı, Ü. (2006). Supplement to the Prosobranchia (Mollusca: Gastropoda) fauna of fresh and brackish waters of Turkey. *Turkish Journal of Zoology* 30 (2): 197-204.
- Yıldız, S., Özbek, M., Taşdemir, A., Balık, S. (2010). Identification of predominant environmental factors structuring benthic macro invertebrate communities: a case study in the Küçük Menderes coastal wetland (Turkey). *Fresenius Environmental Bulletin* 19 (1): 30-36.
- Yıldız, S., Özbek, M., Taşdemir, A., Topkara, E. T. (2015). Assessment of a shallow montane Lentic Ecosystem (Lake Gölçük, İzmir, Turkey) Using Benthic Community Diversity. *Ekoloji* 24 (97): 1-13 doi:10.5053/ekoloji.2015.34.
- Yorulmaz, B., Sukatar, A., Barlas, M. (2015). Comparative analysis of biotic indices for evaluation of water quality of Esen River in South-West Anatolia, Turkey. *Fresenius Environmental Bulletin* 24 (1a): 188-194.
- Zeybek, M. (2017). Macroinvertebrate-based biotic indices for evaluating the water quality of Kargı Stream (Antalya, Turkey). *Turkish Journal of Zoology* 41: 1-11. <https://doi.org/10.3906/zoo-1602-10>
- Zeybek, M., Şahin, S.K. (2016). The Distribution of Trichoptera Assemblages In Relation To Environmental Variables in the Streams of Tunceli (Turkey). *Fresenius Environmental Bulletin* 25 (11): 4972-4981.
- Zeybek, M., Kalyoncu, H., Ertan, Ö.O., Çiçek, N.L. (2012). Benthic Invertebrate Fauna of Köprüçay Stream (Antalya), Süleyman Demirel University Journal of Natural and Applied Sciences 16: 146-153.
- Zeybek, M., Kalyoncu, H., Karakaş, B., Özgül, S. (2014). The use of BMWP and ASPT indices for evaluation of water quality according to macroinvertebrates in Değirmendere Stream (Isparta, Turkey). *Turkish Journal of Zoology* 38 (5): 603-613. <http://dx.doi.org/10.3906/zoo-1310-9>.
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