ORIGINAL ARTICLE

Comparative analysis of benthic macroinvertebrate-based biotic and diversity indices used to evaluate the water quality of Kozluoluk Stream (West Anatolia of Turkey)

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Abstract

Freshwater ecosystems are vitally important which supports biological diversity. With this aim, a total of eight biotic and three species diversity indices were used to determine water quality of Kozluoluk Stream in West Anatolia of Turkey. The biotic indices were: Saprobi (SI), Biological Monitoring Working Party (BMWP-O, BMWP-S and BMWP-G), Average Score per Taxon (ASPT), Family Biotic Index (FBI), Belgian Biotic Index (BBI), EPT-Taxa [%], and species diversity indices consisted of: Shannon–Weaver (SWDI), Simpsons (SDI) and Margalef (MDI). Principal component analysis (PCA) was applied to the physicochemical and biotic dataset. Similarities between the sampling stations were clustered by using cluster analysis (CLUS). Pearson-based correlations were used to determine which index is more suitable in determining water quality of the stream. The nine taxonomic groups were found in Kozluoluk Stream consisting of Amphipoda, Oligochaeta, Gastropoda, Ephemeroptera, Plecoptera, Trichoptera, Odonata, Coleoptera and Diptera. The 1st and 2nd stations (90%) were the most similar stations in terms of benthic macroinvertebrate species distribution. The results indicate that the ASPT, BBI, BMWP-O, BMWP-S, BMWP-G and EPT-Taxa [%] are more proper than FBI and SI indices to determine the water quality of Kozluoluk Stream. The water quality along the stream varied from good class in upstream stations, to moderate in downstream stations. This study clearly showed that the specific biotic index according to the ecological characteristics of Turkey should be developed.

Keywords Bioassessment · Biological indicators · Ecological quality · Biomonitoring

Introduction

The amount of unpolluted water resources is decreasing day by day due to the global warming, increasing population and urbanization (Ertaş et al., 2020, 2021a, b; Manjarrés-Hernández et al., 2021; Sukatar et al., 2020). The various researches, such as biomonitoring methods, have been applied to protect drinking water resources in recent years (Zeybek, 2017). At the beginning of the monitoring studies, the various physicochemical properties of the water source are determined primarily in freshwater systems. In recent years, besides these data, the necessity of knowing the biological richness of fauna has been put forward and many studies on benthic macroinvertebrates have been conducted in Turkey (Başören & Kazancı, 2016; Çamur-Elipek et al., 2010; Duran & Akyıldız, 2011; Kalyoncu et al., 2008; Koşalşahin & Zeybek, 2019; Taşdemir et al., 2010; Zeybek et al., 2012). As a result of the studies, comments can be made about the characteristics of many water sources owing to the species used as ecological indicators.

Biotic indices are the focus of biological monitoring studies based on benthic macroinvertebrates. One of the difficulties in presenting biological observations is summarizing data and presenting it in specific ways. Therefore, various indices are used in Europe for water quality assessment studies using benthic invertebrates (Korycińska, & Królak, 2006). The Saprobi in Germany, Biological Monitoring Working Party—BMWP, Average Score Per Taxon—ASPT, in England, and Belgian Biotic Index—BBI, in Belgium seem to give the most reliable results specific to geographic regions (Yorulmaz et al., 2015). The Yeşilırmak BMWP biotic index (Y-BMWP) was recently developed for use

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only in the Yeşilırmak river basin in Turkey (Kazancı et al., 2013).

Izmir with its historical importance is localizing on the Aegean coast in the West Anatolia of Turkey. Kozluoluk Stream is determined as a study area because it is an important drinking water source for Izmir. The stream is one of the important water sources of the Tahtalı Dam basin in Menderes district of Izmir. Kozluoluk Stream is used as irrigation water source for the surrounding agricultural fields. We hypothesized that the fact that the study area is a residential area that receives migration and the continuation of intensive agricultural activities around the stream causes a negative impact on the quality of the stream. With this reason, this study aims to assess the water quality of the Kozluoluk Stream, using eight biotic indices and three diversity indices accordance with physicochemical characteristics of Kozluoluk Stream. In addition, we aimed to compare the results of biotic and diversity indices in accordance with physicochemical characteristics of Kozluoluk Stream.

Methods

Study area

The study area is located 36 km south of the city centre of Izmir, within the area surrounded by Yeniköy and Efemçukuru villages. The study was carried out monthly at five sampling points in the stream. Sampling stations are given in Fig. 1.

This study was carried out between October 2019 and August 2020. Sampling stations were chosen according to WFD Annex V 1.3.2. (WFD, 2000). Sampling was carried out from each station by using a kick net with classic 50×30 cm in size and 250 μm mesh size according to the literature (AQEM Consortium, 2002). Collected samples were fixed in ethyl alcohol (70%) and formaldehyde (4%) throughout the field study. The samples were categorized and diagnosed to the genus and species level under ZEISS Stereo Discovery.V12 stereomicroscope.

Physicochemical parameters

Water samples were taken and analysed for orthophosphate (PO_4–P), ammoniacal nitrogen (NH_4–N), nitrate (NO_2–N), nitrite (NO_3–N) and biochemical oxygen demand (BOD) using spectrophotometer and proper kits. All analyses were done by following the standard methods (APHA, 2005). Water temperature (ºC), turbidity (TU), pH, electrical conductivity (EC), dissolved oxygen (DO), oxygen saturation (Sat. O_2) were measured in the field by portable equipment (Oxi 315i/ SET WTW Oxygen meter and Waterproof Multiparameter).

Fig. 1 Study area

Data analysis

Saprobic index (SI), Average Score Per Taxon (ASPT), Belgian Biotic Index (BBI), Family Biotic Index (FBI), EPT-Taxa [%], modifications of Biological Monitoring Working Party (BMWP); BMWP-O (Original), BMWP-S (Spanish), BMWP-G (Greek), Shannon–Wiener (SWDI), Simpson's (SDI) and Margalef (MDI) diversity indices were applied on benthic macroinvertebrate data set by using ASTERICS Software Programme (AQEM Consortium, 2002). The Bray–Curtis similarity index was used to determine the similarities between the sampling stations based on macroinvertebrates (Clarke et al., 2006). The unweighted pair-group average linkage (UPGMA) algorithm was used to illustrate similarity-based clustering relationships between sampling stations (Shrestha & Kazama, 2007). Pearson-based correlation analysis was performed by using SPSS version 20.0. PCA was applied to transforms information content in large data tables into a smaller data set that can be more easily visualized and analysed (Liu et al., 2003; Singh et al., 2004, 2005; Varol & Şen, 2009).

Results and discussion

Physicochemical variables

Summary statistics of physicochemical variables are shown in Table 1.

The water temperature values varied between 10.2 and 14.7 °C in Kozluoluk Stream. The highest T°C values were measured in the 5th station, while the lowest T°C values were measured in the 1st station. Although the temperature values are very important in dividing the streams into regions and in the classification of the streams, the temperature in the spring extensions is generally at low levels (Schmitz, 1954). The pH values varied between 6.80 and 7.15 in this stream. The highest pH values were measured in the first three station, while the lowest pH values were measured in the 5th station. The EC values varied between 101 and 223 µS/m in this stream. The highest EC values were measured in the 5th station, while the lowest EC values were measured in the 1st station. It is known that EC values increase as pollution increases in freshwater (Verep et al., 2005). The 5th station is located in an area used as a picnic and agricultural area and is occasionally exposed to the pollutant effect created by humans. The TU values varied between 1.56 and 4.80 ppt in this stream. The highest TU

Table 1 Range, mean and standard deviation values of physicochemical variables in Kozluoluk Stream

Parameters		Station 1	Station 2	Station 3	Station 4	Station 5
T (°C)	R M ± Sd	10.2–11.7	10.5–12.3	10.9–12.8	11.5–13.5	12.1–14.7
		11.0 ± 0.62	11.3 ± 0.75	11.8 ± 0.80	12.5 ± 0.88	13.3 ± 1.12
pH	R M ± Sd	7.00–7.15	7.00–7.15	6.90–7.15	6.90–7.10	6.80–6.90
		7.08 ± 0.06	7.08 ± 0.06	7.01 ± 0.10	6.98 ± 0.10	6.85 ± 0.06
EC (µS/m)	R M ± Sd	101–160	110–168	118–175	131–188	155–223
		129 ± 27.7	138.3 ± 28.5	146.5 ± 28.1	158.8 ± 25.9	187.3 ± 30.9
TU (ppt)	R M ± Sd	1.56–1.70	1.88–1.99	1.95–2.13	3.56–3.95	4.41–4.80
		1.62 ± 0.07	1.93 ± 0.06	2.04 ± 0.09	3.74 ± 0.20	4.60 ± 0.22
DO (mg L^{-1})	R M ± Sd	14.1–15.3	13.9–15.0	13.4–14.9	12.4–14.4	11.0–13.8
		14.7 ± 0.51	14.4 ± 0.46	14.1 ± 0.62	13.5 ± 0.84	12.6 ± 1.19
Sat. O$_2$ (%)	R M ± Sd	129–152	123–150	117–146	112–135	102–122
		141 ± 10.4	136 ± 11.6	129.5 ± 12.9	122.8 ± 9.74	112.5 ± 8.23
BOD (mg L^{-1})	R M ± Sd	0.54–0.99	0.87–1.22	1.12–1.96	1.65–2.28	2.00–2.93
		0.80 ± 0.21	1.05 ± 0.17	1.52 ± 0.41	1.95 ± 0.27	2.49 ± 0.41
NH$_4$-N (mg L^{-1})	R M ± Sd	0.01–0.10	0.01–0.18	0.01–0.31	0.35–1.15	0.55–1.36
		0.05 ± 0.04	0.07 ± 0.08	0.13 ± 0.13	0.74 ± 0.33	0.94 ± 0.34
NO$_2$-N (mg L^{-1})	R M ± Sd	0.02–0.09	0.05–0.33	0.10–0.55	0.35–0.81	0.67–1.42
		0.05 ± 0.03	0.17 ± 0.12	0.31 ± 0.20	0.57 ± 0.21	1.03 ± 0.32
NO$_3$-N (mg L^{-1})	R M ± Sd	0.25–1.05	0.30–1.17	0.65–1.56	0.88–1.88	1.15–2.10
		0.64 ± 0.41	0.76 ± 0.41	1.08 ± 0.44	1.36 ± 0.49	1.61 ± 0.47
PO$_4$-P (mg P L^{-1})	R M ± Sd	0.01–0.05	0.01–0.10	0.05–0.15	0.25–0.67	0.75–1.34
		0.02 ± 0.02	0.04 ± 0.04	0.11 ± 0.05	0.51 ± 0.19	1.09 ± 0.25

R Range; *M* Mean; *Sd* Standard deviation

values were measured in the 5st station, while the lowest TU values were measured in the 1th station. The increase in the amount of suspended solids that prevent the light transmission of water increases the turbidity (Wetzel, 2001). It is recommended not to exceed 1 NTU (turbidity unit) by EPA and World Health Organization (WHO). The DO values varied between 11.0 and 15.3 mg L^{-1} in this stream. The highest DO and Sat. O$_2$ values were measured in the 1st station, while the lowest DO and Sat. O$_2$ values were measured in the 5th station. It is expected that the oxygen value will be low in regions that are under pollution pressure due to the polluting factors in their environments (Kara & Çömlekçioğlu, 2004; Uyanık et al., 2005). The BOD values varied between 0.54 and 2.93 mg L^{-1} in this stream. The highest BOD values were measured in the 5th station, while the lowest BOD values were measured in the 1th station. Kocataş (2008) states that the BOD value of a region gives the amount of organic matter, in other words, the amount of pollutants in that region. The highest NH$_4$–N, NO$_2$–N, NO$_3$–N and PO$_4$ values were measured in the 5th station, while the lowest NH$_4$–N, NO$_2$–N, NO$_3$–N and PO$_4$ values were measured in the 1th station in Kozluoluk Stream. Akyıldız and Duran (2021) stated that these parameters with high values in the downstream of the basin could be explained by the distinct pollutant sources.

Benthic macroinvertebrates

In this study, a total of 1.946 benthic macroinvertebrate individuals were collected; all the specimens collected belong to nine groups: Amphipod, Oligochaeta, Gastropoda, Ephemeroptera, Plecoptera, Trichoptera, Odonata, Coleoptera and Diptera. The maximum numbers of individual were collected at 2nd station (411 individuals), while the minimum numbers of individual were collected at 5th station (352 individuals). Insecta was the most dominant invertebrate group in this stream. The lowest number of individuals was determined in autumn, while the highest number of individuals was determined in spring (Fig. 2). The maximum density of benthic fauna was observed during spring, and this can be related to the availability of phytoplankton population in the form of food supply (Wetzel, 2001). Spring drifts that drive the vegetation have also been one of the factors affecting the amount of benthic fauna. On the other hand, decline in the density of benthic fauna during autumn may be due to increased load of suspended solids, reduced transparency and increased water flow (Ertaş & Yorulmaz, 2021; Ertaş et al., 2020, 2021a, 2021b; Yorulmaz & Ertaş, 2021).

Ephemeroptera was the most dominant group of all season in Kozluoluk Stream (Fig. 3).

Insects are the richest group represented with 19 families: Ephemeroptera (5), Plecoptera (2), Trichoptera (3), Odonata (2), Coleoptera (3) and Diptera (4) that make up 76% of
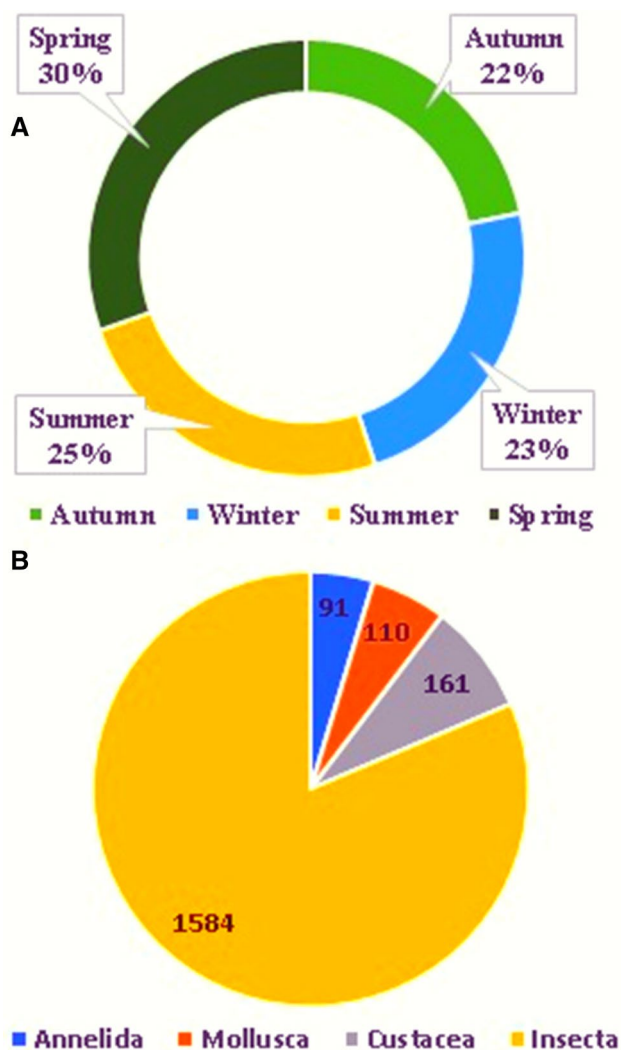
Fig. 2 **a** The seasonal percentages of benthic macroinvertebrates. **b** Benthic invertebrate individuals in Kozluoluk Stream

the macroinvertebrates of the Kozluoluk Stream. Crustacea were represented with 1 family: Gammaridae, which consists 4.16% of macroinvertebrates; Annelida were represented with 1 family: Naididae, which consists 4.16% of macroinvertebrates; and Mollusca were represented with 4 families: Planorbidae, Viviparidae, Bithyniidae and Lymnaeidae, which consists 15.68% of macroinvertebrates.

The dominance of benthic macroinvertebrate species according to the stations is given in Fig. 4. *Gammarus* sp. was dominant at the 3rd, 4th and 5th stations. In Kozluoluk Stream, *Baetis* sp., *Baetis alpinus* Pictet, 1843, and *Baetis rhodani* Pictet, 1843, were dominant in upstream point of the stream. *Hydropsyche* sp. and *Hydropsyche angustipennis* Curtis, 1834, were dominant in downstream point of the stream. In other stream systems, these species are profusely distributed in downstream and are tolerant of organic pollution in rather slow (Stroot, 1984; Faessel, 1985).
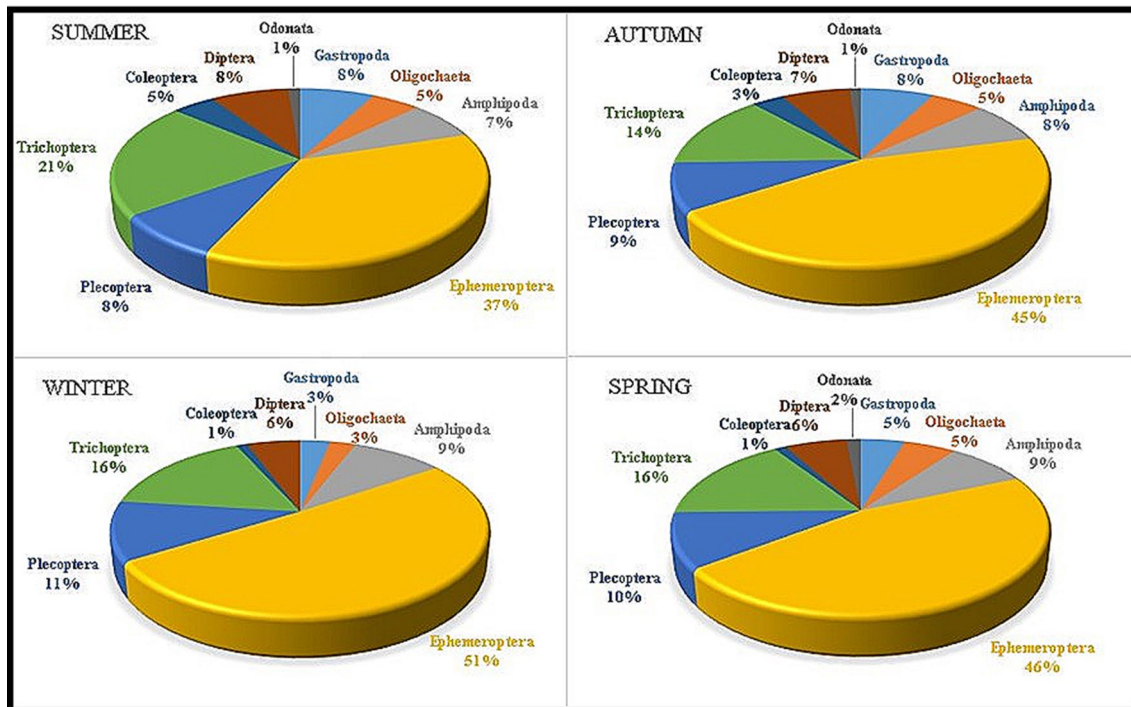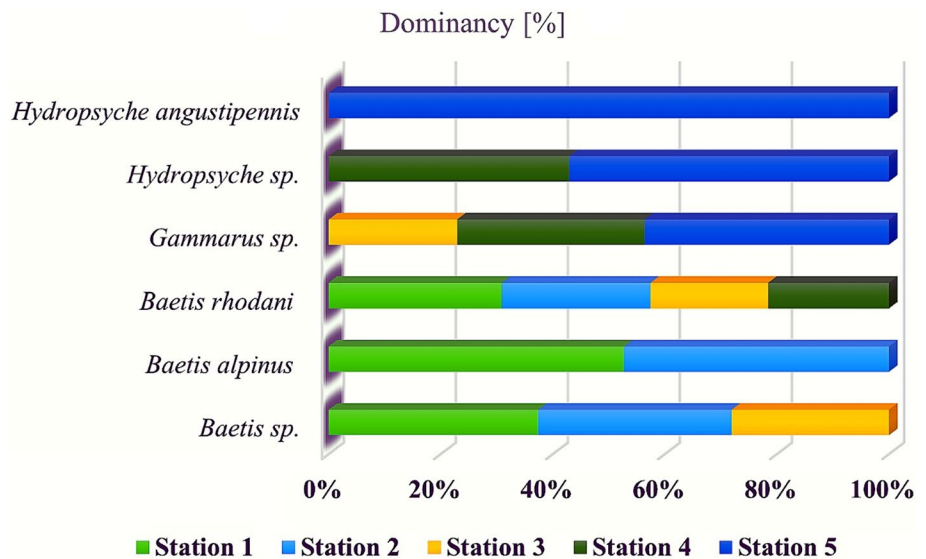
Fig. 3 Distribution of taxonomic groups in Kozluoluk Stream

Fig. 4 Dominancy (%) of benthic macroinvertebrates

The high number of species in 1st, 2nd and 3rd stations is related as the result of increased O_2 level and flow velocity in these stations. These stations are also far from the domestic settlements. In terms of diversity, the richest were sampling 4th station with 22 families each, 8 of them belonging to Ephemeroptera–Plecoptera– Trichoptera (EPT) group that are sensitive to low dissolved oxygen conditions in water (Ertaş & Yorulmaz, 2021). The increase in the percentage of EPT-Taxa leads to an increase in water quality in direct proportional (Ertaş & Yorulmaz, 2021; Lenat, 1993). One Coleoptera, Oligochaeta and Odonata families composed the rest of the macroinvertebrates in 2nd stations. According to Ertaş et al., (2020, 2021a), *Baetis* sp. are predominantly found in the less organically polluted stream section where the water quality is Class I-II. In Selendi Stream, the most dominant taxon in the upstream points of the stream was Ephemeroptera (Yorulmaz & Ertaş, 2021). The number

of EPT families of other stations has decreased compared to the 2nd station.

Cluster analysis dendrogram (UPGMA method) was shown the similarities of the sampling stations (Fig. 5). As a result of the Bray–Curtis similarity index, the 1st and 2nd stations (90%) were the most similar to each other. The second most similar stations to each other were determined at the 4th and 5th stations (81%). Similarity analysis based on benthic invertebrates was frequently used in freshwater studies (Zeybek et al., 2014; Zeybek, 2017; Serdar & Verep, 2018; Koşalşahin & Zeybek, 2019; Yorulmaz et al., 2021).

The ecological structure of Kozluoluk Stream shows that it is under the impact of anthropogenic activities. The biotic and diversity index values and water quality classes of the stations are shown in Table 2.

All diversity indices have shown the highest values in 3rd station, whereas the lowest values are registered in 5th station. These results indicate that the upstream stations of the stream are unpolluted, whereas the reason for the low species diversity at the 5th station is moderately pollution. The 5th station is moderately disturbed due to many domestic and agricultural wastes discharged in this part of the stream. The highest BOD value was seen at the 5th station which showed the presence of organic pollution in the water. BOD represents the amount of oxygen consumed by bacteria and other microorganisms, while they decompose organic matter under aerobic conditions at a specified temperature (Wetzel, 2001). Oxygen depletion in this station is characterized by
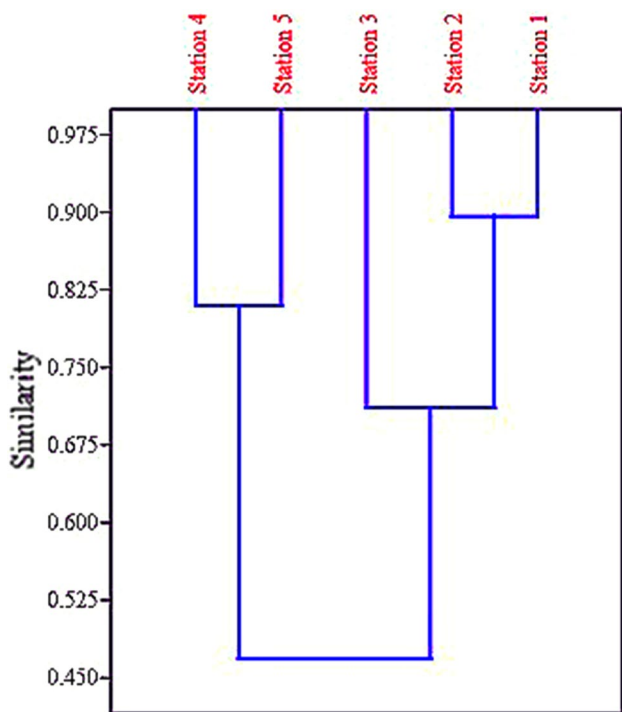
Table 2 Average score values and water quality classes of all indices in Kozluoluk Stream

Metric	Station 1	Station 2	Station 3	Station 4	Station 5
SI	1.821	1.861	1.844	1.813	1.917
Water quality class	II	II	II	II	II
BMWP-O	102	101	89	82	80
Water quality class	II	II	III	III	III
BMWP-S	104	114	100	96	89
Water quality class	II	II	III	III	III
BMWP-G	1048	1128	967	965	853
Water quality class	II	II	III	III	III
ASPT	6.833	6.846	5.882	5.706	5.333
Water quality class	I	I	II	II	II
BBI	10	10	9	9	8
Water quality class	I	I	I	I	II
FBI	4.00	3.92	4.00	4.52	4.57
Water quality class	I-II	I-II	I-II	II	II
EPT-Taxa [%]	85.122	84.428	74.328	57.692	49.716
SDI	0.943	0.951	0.954	0.944	0.924
SWDI	2.984	3.099	3,18	3.081	2.842
MDI	3.989	4.154	4,49	4.409	3.752

Fig. 5 The similarities of the sampling stations

low species diversity. Although diversity indices are insufficient to assess toxicity and physical changes, they are useful for assessing organic pollution and eutrophication (Plafkin et al., 1989; Kalyoncu et al., 2008; Akay & Dalkıran, 2020; Yorulmaz & Ertaş, 2021).

The BMWP-O, BMWP-S and BMWP-G values were highest in 1st and 2nd. These two stations were classified in Class II. The stream water quality is decreasing and becomes of moderate quality (3rd, 4th and 5th stations). BBI index qualifies the water quality at all the stations in Class I-High except 5th station. According to SI, all the stations are Bet-amesosaprob-Class II. According to FBI, the water quality is Class II in all stations of the stream. These index scores indicate that the upstream of the stream with good water quality is under minimal human impact and lack of waste discharge because the region is far from inhabited areas. The physical and chemical change in water quality is moderate in the downstream of the stream which is close to urban and rural areas where human activities are more intense.

The metric that gave the best response to the physicochemical variables of water was EPT-Taxa [%]. These metrics are indicated that Ephemeroptera, Plecoptera and Trichoptera taxa are sensitive to anthropogenic effects, while Oligochaeta taxa are tolerant to anthropogenic effects in

aquatic ecosystems (Ode et al., 2005). In this study, the highest EPT-Taxa [%] values are obtained at the upstream stations. These stations are the upstream part of the stream, and they are less affected by domestic wastes. On the contrary, the 4th and 5th stations are downstream part of the stream. These stations are mostly affected the domestic wastes. The cause of low EPT-Taxa [%] values at the downstream stations in stream is of the pollution that accumulates in the stream as a result of the anthropogenic activities. Other factors depend on the physical properties of the stream such as high temperature, low stream incline and reduction of stream flow.

Our results show that there are differences between indices in water quality classification as a result of applied different indices. It is very difficult to determine the reliability of the index to be chosen for the evaluation of river quality in a country (Yorulmaz & Ertaş, 2021). EPT-Taxa [%], BMWP-O, BMWP-S, BMWP-G and ASPT indices seem more reliable in our research and better reflect the environmental situation, as they are based on the abundance of species sensitive to environmental variables. The fact that Ephemeroptera, Plecoptera and Trichoptera contain groups of organisms that are very sensitive to pollution explains why EPT-Taxa [%] shows high water quality (Lenat, 1993). Our results indicate that high number of EPT-Taxa [%] was reported upstream, in 1st, 2nd and 3rd stations; however, with the increased level of pollution in 4th and 5th stations, the number of EPT families is decreased.

Comparative analysis of biotic indices in stream systems in Turkey has been made on a regional basis in recent years. Kantzaris et al. (2002) stated that the BMWP, ASPT and Land Quality Indicators (LQI) were insufficient in evaluating water quality, while BBI and IBE were proper. Ogleni and Topal (2011) stated that the BMWP and ASPT were sufficient to evaluate water quality. Yorulmaz et al. (2015) applied five biotic indices and noted that the FBI was insufficient in evaluating water quality, while ASPT, BMWP, SI and BBI were appropriate. Zeybek (2017) found that the most appropriate indices for the physical and chemical indices were BMWP-O and ASPT-O and ASPT-C. Yorulmaz and Ertaş (2021) found that the BMWP (Polish), BMWP (Spanish), BMWP (Hungarian), BMWP (Greek) versions and all versions of ASPT indices are more proper than FBI and BBI indices to determine the water quality of Selendi Stream. Ertaş and Yorulmaz (2021) found that the BMWP (Original), BMWP (Spanish), BMWP (Greek) and ASPT indices are suitable for assessing the water quality in Kelebek Stream. Ertaş et al., (2021a, 2021b) found that the BBI, BMWP (Original), BMWP (Spanish) and EPT-Taxa [%] are suitable for assessing the water quality in Karabal Stream.

In this study, the random sample cases *(10% select case)* were made on the biotic indices and physicochemical parameters to verify data sets and to determine that the data were transferred without errors in the SPSS version 20.0. Table 3 indicates the correlations of biotic and diversity indices.

As a result of the correlation analysis, the highest positive significant correlation was found between the BMWP-O, BMWP-S and BMWP-G. The BMWP-O is the positively significant correlated with ASPT *(r- 0.986, p˂0.01)*. ASPT is the positively significant correlated with BBI *(r- 0.969, p˂0.01)*. BMWP-G is the positively significant correlated with BBI *(r- 0.961, p˂0.01)*. The highest negative significant correlation was found between FBI and EPT-Taxa [%] *(r- − 0.963, p˂0.01)*. All the biotic indices are significantly correlated with EPT-Taxa [%], except SI. However, the increase in index values of ASPT, BBI, BMWP-O, BMWP-S and BMWP-G and EPT-Taxa [%] shows good ecological quality.

In this study, the subdivision of sampling points into two groups caused the PCA analysis to show a clear spatial and temporal division. According to PCA analysis, total variance

Table 3 Pearson's correlation assessment between indices

	SI	BMWP-O	BMWP-S	BMWP-G	ASPT	BBI	FBI	EPT-Taxa [%]	SDI	SWDI	MDI
SI	1	− 0.351	− 0.36	− 0.487	− 0.429	− 0.622	0.323	− 0.459	− 0.666	− 0.622	− 0.671
BMWP-O		1	0.887*	0.894*	0.986**	0.931*	− 0.886*	0.965**	0.534	0.28	− 0.028
BMWP-S			1	0.982**	0.912*	0.911*	− 0.857	0.898*	0.726	0.544	0.242
BMWP-G				1	0.940*	0.961**	− 0.805	0.892*	0.712	0.522	0.252
ASPT					1	0.969**	− 0.834	0.943*	0.553	0.305	0.016
BBI						1	− 0.807	0.929*	0.685	0.47	0.229
FBI							1	− 0.963**	− 0.756	− 0.572	− 0.266
EPT-Taxa [%]								1	0.718	0.499	0.205
SDI									1	0.961**	0.818
SWDI										1	0.934*
MDI											1

**Correlation is significant at the 0.01 level (2-tailed)

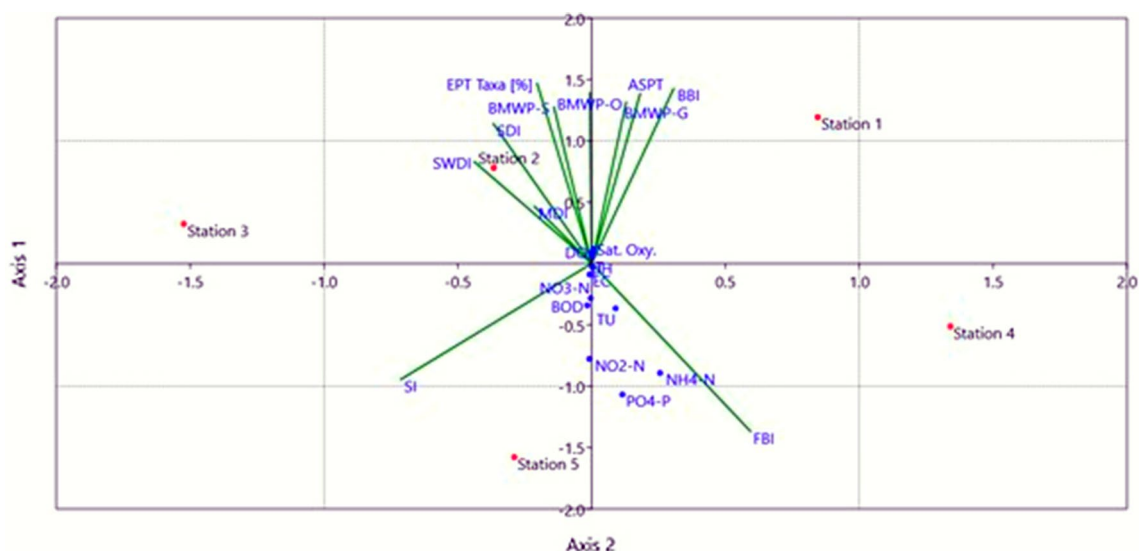*Correlation is significant at the 0.05 level (2-tailed)

Fig. 6 Biplots for PCA analysis of physicochemical variables

was explained as 83.1% in axes 1 and 2 where eigenvalues were greater than 1. High oxygen concentration and species abundance factors are considered in EPT-Taxa [%], BMWP and ASPT (Paisley et al., 2013). BMWP-O, BMWP-S, BMWP-G, EPT-Taxa [%], ASPT and BBI are positively correlated with DO, Sat. O$_2$ and pH in the stream, while they are negatively correlated with PO$_4$–P, NH$_4$–N, NO$_2$–N and NO$_3$–N (Fig. 6). The increase in pollution in the stream ecosystem causes the score values of these indexes to decrease. On the contrary, SI is used to associate species with specific levels of organic pollution (Suryani et al., 2018). SI is positively correlated with PO$_4$–P, NH$_4$–N, NO$_2$–N and NO$_3$–N in the stream. Our PCA results showed similarity with Suryani et al. (2018). In this study, PCA analysis revealed the significant relationship ($p < 0.05$) between indices and physicochemical parameters in Kozluoluk Stream.

Conclusion

The main polluting factors are agricultural runoff and land use, as well as domestic wastewater discharged directly into the stream from the 3rd station. While upstream stations are good quality by populated areas and distance from agricultural activities, in downstream part of the stream is moderately polluted and this is reflected in the macroinvertebrate community and distribution. Increased pollution at 5th station resulted in the disappearance of sensitive species from this part of the stream, and the emergence of more pollution-tolerant species adapted to specific habitats. In our study, ASPT, BBI, BMWP-O, BMWP-S, BMWP-G and EPT-Taxa [%] indices are suitable to assessment water quality of Kozluoluk Stream. The condition of the pollution should be

monitored by conducting intermittent monitoring studies in Kozluoluk Stream. Determination of suitable biotic indices for use in freshwater systems in Turkey and development of a biotic index specific to Turkey are seen as a need.

Declarations

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