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Comparative Performance of the Indices Used for Bioassessment of Water Quality of Sangı Stream (West Anatolia, Turkey)

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Abstract—This study has been carried out to determine water quality of Sangı Stream (West Anatolia, Turkey) and to compare the performance of indices used. Five biotic and three diversity indices have been used for determination of water quality of Sangı Stream. The assessment of water quality has been done based on benthic macroinvertebrate and physicochemical parameters. The following biotic indices have been used: Saprobi Index (SI), Biological Monitoring Working Party (BMWP), Average Score per Taxon (ASPT), Family Biotic Index (FBI), Belgian Biotic Index (BBI), as well as the following diversity indices: Shannon–Weaver index (SWDI), Simpsons index (SDI), Margalef index (MDI) and Evenness (E1). Principal component analysis (PCA) has been applied to the physicochemical variables. The similarities between the sampling stations have been clustered by using Cluster analysis (CLUS). Our results have shown the presence of 9 taxonomic groups in Sangı Stream: Crustacea, Oligochaeta, Gastropoda, Ephemeroptera, Plecoptera, Trichoptera, Odonata, Coleoptera, and Diptera. The water quality along the Sangı Stream has varied from high class quality in station 1, 2, 3 and 4, to good and moderate quality in station 5 and 6. The results indicate that the SI, BMWP, FBI and ASPT were sufficient in the estimation of water quality in the examined watercourse. This study has clearly shown that a specific biotic index according to the ecological characteristics of Turkey should be developed.

Keywords: biomonitoring, ecological quality, biological indicators, biotic index, diversity index

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Rapid population growth, changes in consumption habits and industrial developments from the last half of the 20th century to this time have caused significant water problems both on a global and regional scale [1–4].

While traditional water quality monitoring programs have focused on physicochemical monitoring, the limnologists have recently been increasingly reliant on biological assessments that provide important information about freshwater ecosystem conditions [5–18].

Biomonitoring studies by using bioindicators allow us to have information about the effects (chronic) that the aquatic habitat has been exposed to in the past [19, 20]. The most important advantage of using bioindicator groups to characterize the general condition of water is that they do well in reflecting the historical past of the stress sources in a region. Benthic macroinvertebrates form one of the indicator groups mostly used in determining the water quality [16].

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 [21]. The Saprobi index in Germany, Biological Monitoring Working Party (BMWP) and Average Score Per Taxon (ASPT) in England, Belgian Biotic Index (BBI) in Belgium all seem to give the most reliable results specific to their geographic regions. The Yeşilırmak BMWP biotic index (Y-BMWP) has been recently developed for use only in the Yeşilırmak river basin in Turkey [22].

This study aims to assess the water quality of Sangı Stream. In addition, we aim to compare the results of five biotic indices and three diversity indices correlation with physicochemical characteristics of Sangı Stream (West Anatolia, Turkey).

MATERIALS AND METHODS

Study Area

Izmir, an area of historical importance, is located on the Aegean coast in West Anatolia of Turkey. Sangı Stream has been chosen 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

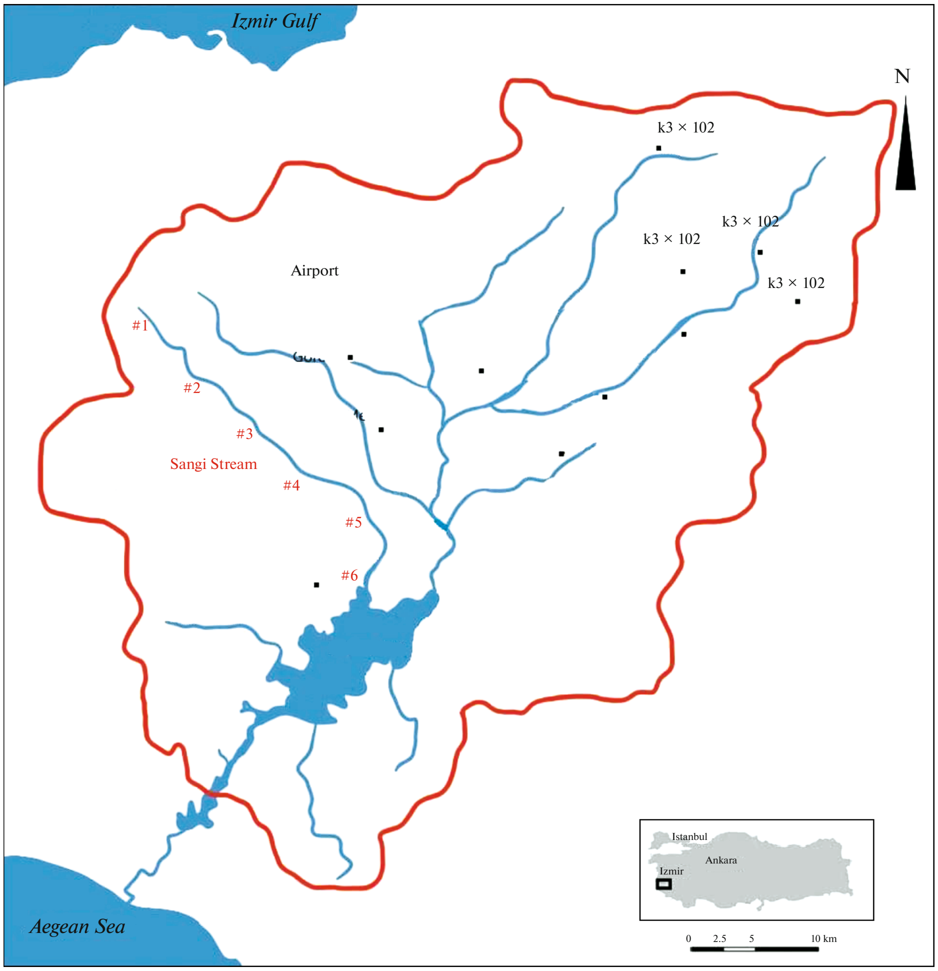

Fig. 1. Map of the sampling stations in Sangı Stream.

Dam basin in the Menderes district of Izmir. Sangı Stream is also used as a water source for irrigating the surrounding agricultural fields.

This study has been carried out on Sangı Stream in the Tahtali Dam Basin in Western Turkey. The length of the Sangı Stream is 25 km^2. Sangı Stream flows from the Sandı Mountain (700 m) to the west of Tahtali Dam (Fig. 1).

The sampling stations have been chosen according to the criteria for selecting operational monitoring sites given in WFD Annex V 1.3.2. [23]. The research has been conducted from February 2018 to March 2019 at six monitoring stations that have included the upstream (stations 1, 2, 3) and downstream (stations 4, 5, 6) parts of the stream. The sampling has been carried out on monthly in over a year at Sangı Stream. The characteristics of the sampling stations are presented in Table 1.

The sampling has been carried out from each station by using a kick-net with the classic 50 × 30 cm size and 250 µm mesh size according to the guidelines in scientific literature [24]. The collected samples have been fixed in ethyl alcohol (70%) and formaldehyde (4%) throughout the field study. The samples have been categorized and diagnosed to the lowest possible taxonomic level under a stereomicroscope.

Physicochemical Parameters

Simultaneously with macroinvertebrate sampling, water samples have been taken and analysed for the following parameters, PO_4-P, NH_4-N, NO_2-N, NO_3-N, Cl^- and BOD_5, using spectrophotometer and the proper kits. All analyses have been done by following the standard methods [25]. Water temperature (°C), pH, electrical conductivity (EC) and dissolved oxygen (DO) have been measured in the field using portable equipment.

Data Analysis

Saprobi Index (SI), Average Score Per Taxon (ASPT), Belgian Biotic Index (BBI), Family Biotic Index (FBI), Biological Monitoring Working Party

Table 1. Key characteristics of sampling stations in Sangı Stream

№	Sampling station	Coordinates and altitude (m)	Habitat	Stream morphology	Riparian vegetation
1	The source point of the stream	38°°16′ N 27°00′ E 507	Large rocks (>50 cm) mixed with gravel and wood debris	No macrophytes have been present	It's not well developed
2	The upstream part of the Sangı Stream is where the water of the Segen pond flows into the stream	38°15′ N 27°00′ E 411	Large rocks, gravels, wood debris, and silt	No macrophytes have been present	Well-developed on right side
3	Sangı Stream in village of Çatalca. Agricultural areas are intense around the stream	38°15′ N 27°03′ E 234	Large stones and gravel	Segen pond changes the water level and flow velocity in Sangı Stream	Well-developed on left side
4	Sangı Stream in village of Çatalca. Agricultural areas are intense around the stream	38°13′ N 27°06′ E 125	Sand, gravel, silt, and cobbles	Agricultural runoff. Macrophytes present	Well-developed on both sides
5	This station is under the pressure of fish farms and domestic settlements	38°12′ N 27°08′ E 73	Cobbles, pebbles, sand, and mud	Streambed with agricultural runoff. Macrophytes present	Well-developed on both sides
6	This station is located at the point where the stream drains into Tahtalı Dam Lake	38° 10′ N 27° 07′ E 59	Cobbles, pebbles, sand, and mud	Streambed with agricultural runoff. Macrophytes present	Well-developed on both sides

(BMWP), Shannon–Wiener (SWDI), Simpson's (SDI), Margalef (MDI) and Evenness (E1) indices have been applied on benthic macroinvertebrate data set by using ASTERICS Software Program [24]. The Bray–Curtis similarity index has been used to determine the similarities between the sampling stations based on macroinvertebrates [26]. The UPGMA algorithm has been used to illustrate similarity-based clustering relationships between sampling stations [27]. Pearson's based correlation analysis has been performed by using SPSS version 20.0. PCA has been applied to transform the content from large data tables into a smaller data set that can be more easily visualized and analysed [28–31].

RESULTS AND DISCUSSION

The results of the analysed physicochemical variables of the water in six sampling stations located along the stream are presented in Table 2.

The mean value of *T*°C has varied from 11.9°C in station 1 in the source area of the stream, up to 16.5°C in stations 4 and 5. On the other hand, pH has shown small alteration, with minimum value of 6.80 in station 4 and maximum value of 7.11 in station 1, meaning that in all stations the stream water is alkaline [32, 33].

The increase in EC in drinking water indicates that the water is contaminated, or that sea water is mixed into the water. According to the One-Way Anova test, EC has varied significantly between stations ($p < 0.05$). The highest mean value of EC in this study has been recorded in station 4 (369.2 μS/m) in the downstream area.

Dissolved oxygen is a vital variable for a healthy aquatic life [34, 35]. The mean value of DO concentration has varied from 13.4 mg/L (station 1) to 9.65 mg/L (station 4). BOD_5 is the amount of dissolved molecular oxygen used by microorganisms during the 5-day incubation period to oxidize the structure of organic substances in water at 20°C. The mean values of BOD_5 in sampling stations has ranged from 1.16 mg/L in station 1 to 4.75 mg/L in station 4 [32, 33]. According to the One-Way Anova test, BOD_5 has varied significantly between stations ($p < 0.05$).

Elements that limit efficiency in aquatic environments are mostly PO_4-P, NH_4-N, NO_2-N, NO_3-N [36]. The NO_3-N range has been from 0.78 mg/L in station 1 to 2.55 mg/L in station 4. The increase of NO_3- in station 4 and 5 has shown these two stations to be rich with nutrients caused by discharges of agricultural and domestic wastes in the vicinity of Sangı Stream. The minimum mean value of PO_4-P has been 0.04 mg/L, registered in stations 1 and 2, and the maximum has been 3.19 mg/L in station 4. The minimum mean value of NO_2-N has been 0.08 mg/L in station 1, and the maximum has been 2.66 mg/L in station 4. The minimum mean value of NH_4-N has been 0.05 mg/L in

Table 2. Summarized statistics of physicochemical parameters in sampling stations

Parameters		Stations					
		1	2	3	4	5	6
T, °C	R	11.0–12.8	11.6–12.8	12.1–13.7	14.5–17.9	15.8–17.5	14.2–17.4
	M ± Sd.	11.9 ± 0.74	12.3 ± 0.51	12.8 ± 0.66	16.5 ± 1.45	16.5 ± 0.71	15.8 ± 1.33
pH	R	7.0–7.25	7.0–7.10	6.9–7.10	6.7–6.90	6.7–7.00	6.7–7.00
	M ± Sd.	7.11 ± 0.10	7.04 ± 0.04	7.00 ± 0.08	6.80 ± 0.08	6.85 ± 0.12	6.87 ± 0.12
EC, μS/m	R	132–187	145–193	163–247	303–422	221–269	201–255
	M ± Sd.	154.2 ± 24.1	165.2 ± 20.7	203 ± 34.4	369.2 ± 49.6	243.2 ± 20.8	227.5 ± 22.1
DO, mg/L	R	13.1–13.8	13.0–13.7	12.6–13.1	9.0–10.0	10.1–11.7	10.2–12.1
	M ± Sd.	13.4 ± 0.28	13.2 ± 0.31	12.8 ± 0.20	9.65 ± 0.44	11.0 ± 0.66	10.8 ± 0.85
BOI_5, mg/	R	1.08–1.25	1.11–1.33	1.28–1.88	3.99–5.34	2.64–3.56	2.21–3.02
	M ± Sd.	1.16 ± 0.07	1.22 ± 0.09	1.56 ± 0.26	4.75 ± 0.56	3.16 ± 0.39	2.68 ± 0.34
NH_4-N, mg/L	R	0.03–0.08	0.05–0.10	0.12–0.32	2.99–4.38	1.13–2.69	0.72–1.10
	M ± Sd.	0.05 ± 0.02	0.07 ± 0.02	0.20 ± 0.08	3.72 ± 0.57	1.55 ± 0.76	0.91 ± 0.15
NO_2-N, mg/L	R	0.06–0.10	0.07–0.14	0.08–0.19	2.13–3.22	1.07–1.89	1.02–1.36
	M ± Sd.	0.08 ± 0.01	0.09 ± 0.03	0.11 ± 0.04	2.66 ± 0.45	1.44 ± 0.35	1.13 ± 0.15
NO_3-N, mg/L	R	0.66–0.92	0.81–0.99	1.07–1.18	2.43–2.74	1.44–1.88	1.25–1.62
	M ± Sd.	0.78 ± 0.11	0.91 ± 0.07	1.11 ± 0.04	2.55 ± 0.14	1.62 ± 0.18	1.39 ± 0.16
PO_4-P, mg/L	R	0.03–0.06	0.03–0.08	0.05–0.13	2.88–3.67	1.01–1.19	0.77–1.12
	M ± Sd	0.04 ± 0.01	0.04 ± 0.02	0.08 ± 0.03	3.19 ± 0.34	1.08 ± 0.08	0.93 ± 0.14
Cl^-, mg/L	R	1.93–2.23	2.21–2.98	2.67–3.24	6.97–9.25	3.12–6.33	4.10–4.55
	M ± Sd	2.07 ± 0.12	2.65 ± 0.34	2.92 ± 0.24	8.46 ± 1.02	5.39 ± 1.52	4.22 ± 0.21

R—range; M ± Sd—mean and standard deviation.

station 1, and the maximum has been 3.72 mg/L in station 4. According to the One-Way Anova test, PO_4-P, NH_4-N, NO_2-N, NO_3-N have varied significantly between stations ($p < 0.05$).

In this study, the subdividing of the sampling points into two groups has caused the PCA analysis to show a clear spatial and temporal division (Fig. 2). According to PCA analysis, total variance has been explained as 93.9% in axis 1 and 2 where eigenvalues have been greater than 1. PCA 1 has positive loading on temperature, ToC, EC, BOI_5, NH_4-N, NO_2-N, NO_3-N, Cl^- and PO_4-P and negative loading on DO and pH. Positive loadings on NH_4-N, NO_2-N, NO_3-N and PO_4-P have been related to organic pollution. Thus, the resulting components of PCA analysis represent pollution from agricultural and domestic wastewaters.

Table 3. Distribution of taxonomic groups (%)

Taxonomic group	Stations					
	1	2	3	4	5	6
Gastropoda	–	–	0.75	1.02	5.97	7.57
Oligochaeta	–	–	0.43	0.68	5.33	6.11
Crustacea	–	1.97	11.82	11.55	2.21	1.34
Ephemeroptera	50.70	46.68	36.20	32.96	34.16	34.19
Odonata	–	–	0.75	0.91	0.91	–
Plecoptera	14.96	14.94	13.96	14.84	15.20	14.65
Trichoptera	14.76	16.81	17.19	17.55	20.26	20.76
Coleoptera	6.23	5.50	4.83	4.42	–	–
Diptera	13.35	14.11	14.07	16.08	15.97	15.39

In this study, a total of 5.363 benthic macroinvertebrate samples have been collected, belonging to nine groups: Crustacea, Oligochaeta, Gastropoda, Ephemeroptera, Plecoptera, Trichoptera, Odonata, Coleoptera and Diptera. Among all the taxonomic groups the following have been dominant: Ephemeroptera in station 1 (50.7%); Diptera in stations 2, 5 and 6 (14.1, 15.9 and 15.3%); and Crustacea in stations 3 and 4 (11.8, 11.5%) (Table 3).

EPT-Taxa (%) has been one of the metrics with the best response to the physicochemical variables of freshwater. It is indicated that EPT taxa are sensitive to anthropogenic factor while Oligochaeta taxa are tolerant to anthropogenic factor in freshwater ecosystems [37]. In this study, the highest EPT-Taxa values have been obtained in station 1 (75%) during all seasons while the lowest EPT-Taxa values have been obtained in station 2 (57.1%) in autumn (Table 4).

Indicator organisms that define the condition of the environment are used in biological monitoring

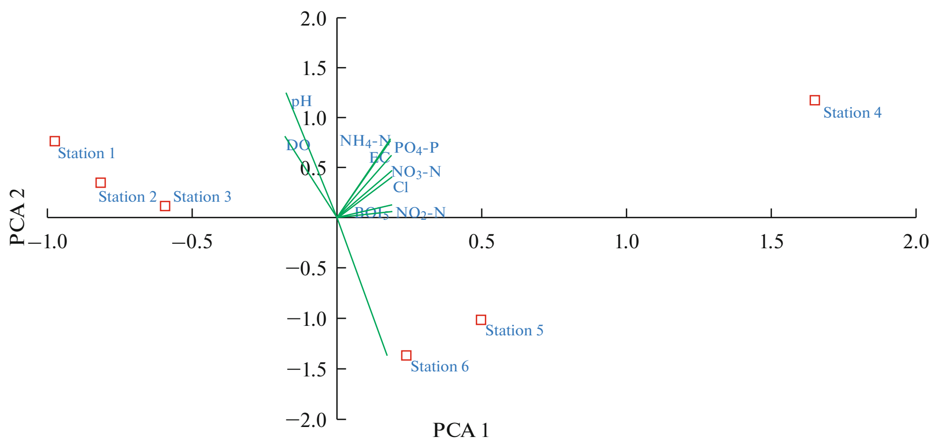

Fig. 2. Biplots for PCA analysis of water quality in Sangı Stream.

studies. Bacteria, protozoans, algae, benthic macroinvertebrates, macrophytes and fish can be used as indicator organisms [38]. Benthic macroinvertebrates are the most advantageous group among all these groups. Habitat demands of benthic macroinvertebrates are more limited than other groups. Their mobility is lower. They are not displaced when they are affected by adverse conditions and they can be tracked more easily in the event of changes in community components and the loss of susceptible species. It is easier to diagnose, gather and hide than some other groups. It is found at any time of the year and its life cycles take longer than some other groups [39–45].

Cluster analysis dendrogram (UPGMA method) shows the similarities of the sampling stations (Fig. 3). According to the Bray–Curtis similarity index, the stations 1 and 2 (94%) have been the most similar to each other. The second most similar stations to each other have been determined to be stations 3 and 4 (93%). All of these close similarities and dissimilarities are likely related to the ecological and physical characteristics of the sampling stations. If we compare the bottom structure and physical characteristic of these stations, the matching sampling points are fairly similar to each other while stations 5 and 6 are different from the others. The bottom structure of stations 5 and 6 has a sandy-muddy sediment type because of their low incline and flow. These stations are close to the Tahtali Dam.

The biotic indices indicate that the Sangı Stream is slightly polluted by agricultural activities. Table 5 summarizes the biological quality scores and quality classes in Sangı Stream. Water quality classes have varied from moderate (according to BMWP 5th and 6th) to high class. According to the BMWP (original), the highest score values have been obtained in stations 1 and 2 while the lowest scores have been obtained in stations 5 and 6. According to ASPT (original), the highest score values have been obtained in station 1 while the lowest scores have been obtained in station 6. According to the SI, the water quality class is oligosaprobic/betamesosaprobic at sites 1, 2 and 3 (Class I–II) while the water quality class is betamesosaprobic at sites 4, 5 and 6.

The average species diversity of the stations has been determined by using SDI, SWDI and MDI in Sangı Stream. According to SDI, the highest diversity values have been obtained in stations 1 and 2 while the lowest scores have been obtained in stations 5 and 6. According to SWDI, the highest diversity values have been obtained in station 2 while the lowest scores have been obtained in station 4. According to MDI, the highest diversity values have been obtained in station 2 while the lowest scores have been obtained in station 6. Species richness is a simple number of species, while species evenness determines how equal the abundance of species is. [46]. The low evenness value indicates that there is no balance in distribution of the species and the community is dominated by a taxon or some taxa [47]. According to [48], if the SWDI value is higher than “3”, it indicates unpolluted water; if the diversity value is between 1 and 3, it indicates moderate pollution, and a value smaller than “1” indicates heavy pollution. According to [49], the diversity value ranges from 0 (low density) to 1 at SDI.

Comparative analyses of biotic indices in stream systems in Turkey have been made on a regional basis in recent years [8, 14, 17, 18, 50–55].

Table 4. Distribution of seasonal EPT-Taxa values (%)

	Stations					
	1	2	3	4	5	6
Summer	75.00	73.63	59.12	58.64	64.44	65.65
Autumn	72.00	71.71	63.86	60.41	60.84	57.14
Winter	87.77	85.08	75.89	74.18	76.34	77.16
Spring	83.62	80.35	67.46	65.00	72.25	72.95

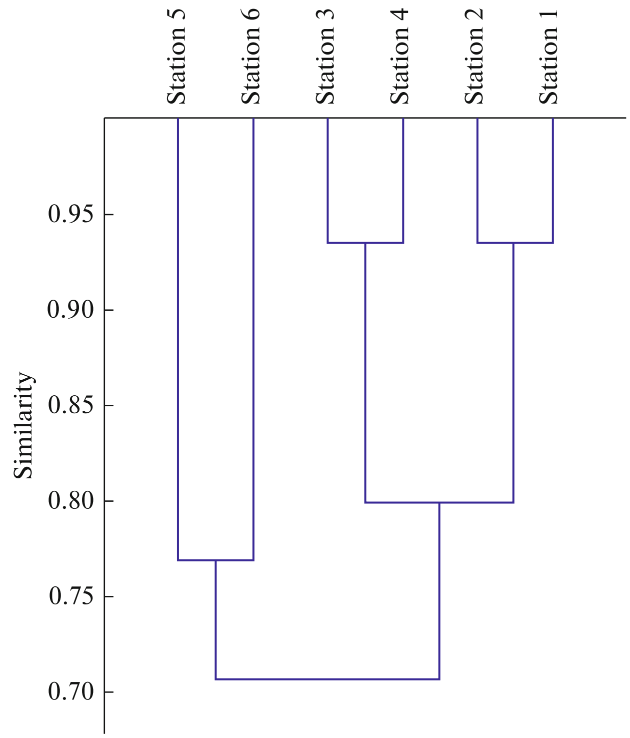

Fig. 3. The similarities between sampling stations.

In this study, the random sample cases (10% select case) have been made on the basis of biotic indices and physicochemical parameters to verify data sets and to determine that the data has been transferred without errors in the SPSS version 20.0. Table 6 indicates the correlations of biotic and diversity indices.

Table 5. Average score values and water quality classes of all indices

Metric	Stations					
	1	2	3	4	5	6
SI	1.735	1.735	1.735	1.917	1.943	1.974
Water quality class	I–II	I–II	I–II	II	II	II
BMWP (original)	121	121	101	101	95	93
Water quality class	II	II	II	II	III	III
ASPT (original)	6.786	6.733	6.368	6.368	6.412	6.200
Water quality class	I	I	I	I	I	I
BBI	10	10	10	10	9	9
Water quality class	I	I	I	I	I	I
FBI	3.86	3.93	4.09	4.32	4.44	4.39
Water quality class	I–II	I–II	I–II	II	II	II
SDI	0.961	0.961	0.953	0.951	0.960	0.960
SWDI	3.297	3.317	3.22	3.172	3.253	3.253
MDI	4.201	4.366	4.535	4.423	4.213	4.025
E1	0.969	0.966	0.929	0.924	0.966	0.976

As a result of the correlation analysis, SI has a significant positive correlation with FBI ($r = 0.942$, $p < 0.01$). BMWP (original) has a significant positive correlation with ASPT (original) ($r = 0.848$, $p < 0.01$), while BMWP (original) has a significant negative correlation with FBI ($r = -0.795$, $p < 0.01$). On the other hand, BMWP (Original) has a significant negative correlation with SDI ($r = -0.841$, $p < 0.01$). Note that the increase in index values of SI, FBI, BMWP and ASPT shows good ecological quality, while the increase in BBI shows bad ecological quality.

Table 7 summarizes the Pearson correlation analyses between the biotic and diversity indices and the physicochemical parameters. A significant correlation has been found between T°C and SI ($r = -0.751$, $p < 0.05$), between pH and SI ($r = 0.826$, $p < 0.05$), and between DO and SI ($r = -0.751$, $p < 0.05$). According to correlation between physicochemical parameters and indices, a significant correlation value has been determined between NO_2-N, BOI_5, T°C, pH and DO and BMWP (original) and SWDI. All physicochemical parameters except T°C and pH have shown a significantly correlation with BBI. According to the analysis results, the benthic macroinvertebrates are sensitive to changes in temperature and oxygen in water, and as temperature increases and oxygen decreases, sensitive organisms are replaced by tolerant organisms [56].

Table 6. Pearson's based correlation assesment between biotic and diversity indices in Sangı Stream

Metric	SI	BMWP	ASPT	FBI	BBI	SDI	SWDI	MDI
SI	1	–0.427	–0.747	0.942**	–0.791	–0.066	–0.464	–0.541
BMWP		1	0.848**	–0.795*	0.790	–0.841*	–0.583	0.818*
ASPT			1	–0.856*	0.577	0.452	0.704	0.138
FBI				1	–0.765	–0.240	–0.597	–0.308
BBI					1	–0.405	–0.015	0.740
SDI						1	0.904*	–0.704
SWDI							1	–0.374
MDI								1

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 7. Pearson's based correlation assesment between biotic indices and species diversity indices and physicochemical parameters

Parameters		SI	BMWP	ASPT	FBI	BBI	SDI	SWDI	MDI
N		6	6	6	6	6	6	6	6
T, °C	Pearson correlation	–0.751*	0.963**	–0.649	–0.291	–0.641	–0.280	0.954**	–0.214
	p	0.043	0.001	0.082	0.288	0.085	0.295	0.002	0.342
DO	Pearson correlation	0.751*	–0.902**	0.496	0.426	0.735*	0.203	–0.915**	0.059
	p	0.043	0.007	0.158	0.200	0.048	0.350	0.005	0.456
pH	Pearson correlation	0.826*	–0.954**	0.569	0.416	0.719	0.161	–0.915**	0.116
	p	0.021	0.002	0.120	0.206	0.053	0.380	0.005	0.414
EC	Pearson correlation	–0.585	0.680	–0.083	–0.719	–0.880*	0.189	0.650	0.348
	p	0.112	0.069	0.438	0.054	0.010	0.360	0.081	0.250
BOI_5	Pearson correlation	–0.604	0.784*	–0.276	–0.555	–0.797*	–0.006	0.785*	0.145
	p	0.102	0.033	0.298	0.127	0.029	0.495	0.032	0.392
NH_4-N	Pearson correlation	–0.461	0.639	–0.079	–0.621	–0.795*	0.124	0.649	0.289
	p	0.179	0.086	0.441	0.094	0.029	0.408	0.082	0.289
NO_2-N	Pearson correlation	–0.555	0.759*	–0.272	–0.507	–0.753*	–0.050	0.787*	0.112
	p	0.126	0.040	0.301	0.153	0.042	0.463	0.032	0.416
NO_3-N	Pearson correlation	–0.572	0.712	–0.138	–0.662	–0.844*	0.145	0.688	0.277
	p	0.118	0.056	0.397	0.076	0.017	0.392	0.065	0.298
PO_4-P	Pearson correlation	–0.475	0.624	–0.070	–0.616	–0.789*	0.085	0.657	0.284
	p	0.170	0.093	0.448	0.097	0.031	0.436	0.078	0.293
Cl^-	Pearson correlation	–0.537	0.720	–0.172	–0.603	-0.799*	0.104	0.708	0.219
	p	0.136	0.053	0.373	0.102	0.028	0.423	0.058	0.338

* Correlation is significant at $p < 0.05$.
** Correlation is significant at $p < 0.01$.

CONCLUSIONS

According to the results, it can be predicted that the pollution factors from intense agricultural activities and urbanization may cause serious pollution pressure on Sangı Stream in the future. This study shows that the BMWP, ASPT, FBI and SI appear to be more appropriate than the BBI. The BBI implemented in various streams studies in Turkey has shown reliable results reflecting the quality of the streams. However, BBI has not shown a significant correlation with other indexes used in Sangı Stream. The fact that there are very few similar studies makes it difficult to determine their availability in Turkey. More studies are needed on this subject, and they should be carried out in streams in different regions.

Intermittent monitoring studies should be carried out in the Tahtalı Dam basin to prevent the negative effect from waste. This study shows that there is a great need for development of a reference biotic index for Turkey to assess surface waters in Turkey with high accuracy. The development of a Turkish biotic index will also enable it to be used in Mediterranean and Aegean countries with similar climatic and geographical characteristics. This index will be an important criterion for determining the water quality of freshwater ecosystems on a global scale. Therefore, this study is very important in terms of data generation.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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