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Benthic Macroinvertebrates from Darıören and Isparta Streams (Isparta/Turkey) – Biotic Indices and Multivariate Analysis

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Abstract

During 2003 -2004, seventy-two samples were collected from 6 sampling points on Isparta stream basin (Isparta/Turkey). Macrozoobenthic organisms and physico-chemical parameters were investigated to assess the impact of the pollution on macrozoobenthos assemblages. Ecological methodologies (species richness, diversity and family biotic indices and multivariate analysis) were employed to assess the impact of the pollution on macrozoobenthic assemblages. During the study, totally 27293 specimens were collected from six sampling points. These belonged to 83 taxa distributed into 6 taxonomic groups as follows: Plathelminthes, Mollusca, Annelida, Crustacea, Insecta, and Arachnida. Biological oxygen demand, NH_4-N, NO_3-N, NO_2-N SO_4, conductivity, total hardness and turbidity parameters were measured higher in the 3rd and 6th sampling points, while dissolved oxygen amount was the lowest in these. pH was variable. In this study, the number of species is the highest at station 1, which is also reflected by Margalef and Shannon-Weaver indices. As the amount of pollution is higher at stations 3 and 6, the number of species is fewer in these stations compared to the others. Sampling points 1, 2, 4 and 5 were of good water quality levels. Changes in water quality levels were better reflected by species richness, diversity indices and principal component analysis than pollution indices in Isparta stream.

Key words: Water quality, benthic macro-invertebrates, Darıören and Isparta streams, Turkey

INTRODUCTION

Biological water quality can be identified by using different kinds of organisms; diatoms, aquatic vegetation, invertebrates, fishes and some other vertebrates. The structure of macroinvertebrate communities has been the subject of many researches on river systems [e.g. 1, 2]. Macroinvertebrate data are used in biological monitoring of water quality, and their relative advantages over other groups of aquatic organisms for this purpose are well documented [3, 4, 5]. The advantage of using macroinvertebrates as bioindicators is that macroinvetebrate communities reflect overall ecological quality. Species richness is an integrative descriptor of the community, as it is influenced by a large number of natural environmental factors as well as anthropogenic disturbances [6]. The combination of ecological parameters (frequency, dominance, indices of diversity, and similarity) provides a precise picture on the changes in the structure of macrozoobenthos [1]. Several studies maintained that human impact decreases macroinvertebrate density [7, 8, 9, 10, 11]. Diversity and biotic indices may be influenced not only by pollution, but by any stress [12, 13, 14]. Therefore, species richness is also used as a biological indicator of disturbance.

The aim of the study is to use diversity indices and Family Biotic Indices used European and other Countries; to see how these indices will in evaluating the water quality of Isparta stream.

MATERIAL AND METHOD

Six sampling points were chosen on Isparta Stream which is 50 km long. First sampling point is the source area located at northern side of Akdağ Mountain, Yukarı Direkli village (1200 m. alt.) which has no waste water connection. By the border of Aşağı Direkli village, waste water from Isparta town is discharged to Isparta stream. 2nd sampling point is located at the end of Direkli stream. The 3rd sampling point is on the main road between Antalya and Isparta, 4th sampling point is near Darıören village. 5th sampling point is on Darıören stream that joins to Isparta stream, 6th sampling point is in Dereboğazı area by Isparta-Antalya main road (Figure 1).

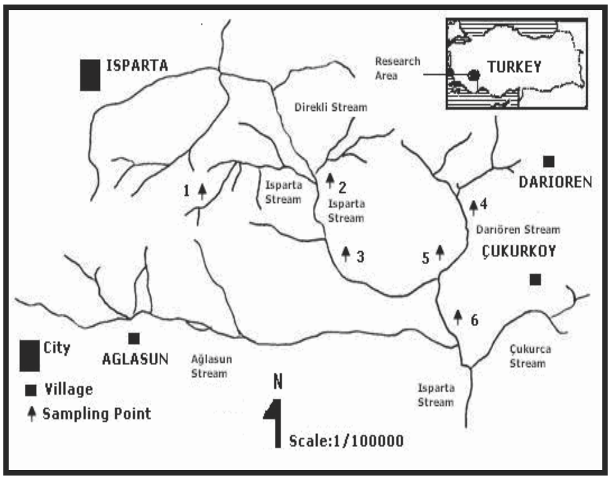

Figure 1. Isparta Stream and sampling points

During the study period (June 2003-May 2004), samples were taken monthly in the middle of each month except rainy days to avoid negative effects of the flood and temporary organisms. When choosing the sample points in the stream, we took into consideration all those influencing the stream water quality, such as tributaries and mixing points of waste-water discharge. With respect to these facts, we have chosen 6 points which represent the system adequately, starting from the place which is nearest to the source of the Isparta River.

Benthic macroinvertebrates were sampled at each site using handnet in the various substrate types present (e.g. silt, gravel, sand) within the sampling points [11]. Totally 72 samplings were done collect water and macrozoobenthic samples –monthly–

at the 6 stations determined. Benthic macroinvertebrate samples were preserved on the field with 70% alcohol and later separated in the laboratory. The samples from each site were composited, identified to the lowest possible taxon and counted. Diversity indices were obtained by using the formula of Margalef (M) and of Shannon and Weaver (SW) as detailed in Ludwig and Reynolds [15]. The Family Biotic Index calculations (FBI) were based on Hilsenhoff [8]. An ordination of the sampling points based on benthic macroinvertebrates data were realized

by carrying out a principal component analysis (PCA) of a correlation matrix which was calculated considering only those species of relative abundance > 5% (Table 1). Variance normality was attained by logarithmic transformation of data (

Another PCA was carried out based on a correlation matrix which included both biological information (diversity index, number of species and Family biotic index) and physical –chemical variables (pH, conductivity, dissolved oxygen (DO), biological oxygen demand (BOD5), ammonium nitrogen, nitrite nitrogen, nitrate nitrogen, total hardness, turbidity, and SO4 [16]. To evaluate the relationship between the applied methodology and the physico-chemical characteristics of water, a step-wise multiple regression was calculated. Pearson's correlation coefficients were also obtained.

RESULTS

Water quality: Not being contaminated, water quality values at the stations of 1, 2, 4 and 5 have been affected by the geological structure. At the sampling points of 3 and 6, water quality has been affected by the waste water coming from Isparta. During the sampling period temperature varied between

9.9 and 16.9 0C. The BOD$_5$, PO$_4$-P, NH$_4$-N, NO$_3$-N, SO4, Cl and Conductivity showed highest values especially at sampling points of 3 and 6 (Figure 2). pH values of sampling points vary between 7.5- 8.5. Dissolved oxygen decreased downstream on sampling points of 3 and 6 (Figure 2). Values varied between the following amounts: DO values 1,5 (sampling point 3) - 9,9 (sampling point 1) mg/L-1, BOD5 values 1 (sampling points 1, 2, 4 and 5) - 84 (sampling point 3) mg/L-1, PO4-P values 0 (sampling points 1, 2, 4 and 5) - 16,1 (sampling point 3) mg/L-1, NH4-N values 0 (sampling points 1 and 2) – 6,19 mg/L-1 (sampling point 6), NO3-N values 0 (sampling point 1) – 3,33 (sampling point 6) mg/L-1, SO4 values 2,3 (sampling point 1) - 120,3 (sampling point 3) mg/L-1, Cl values 2,8 (sampling point 1) - 75,2 (sampling point 6) mg/L-1 and conductivity values 215 (sampling point 1) – 980 (sampling point 3) µmhos/cm.

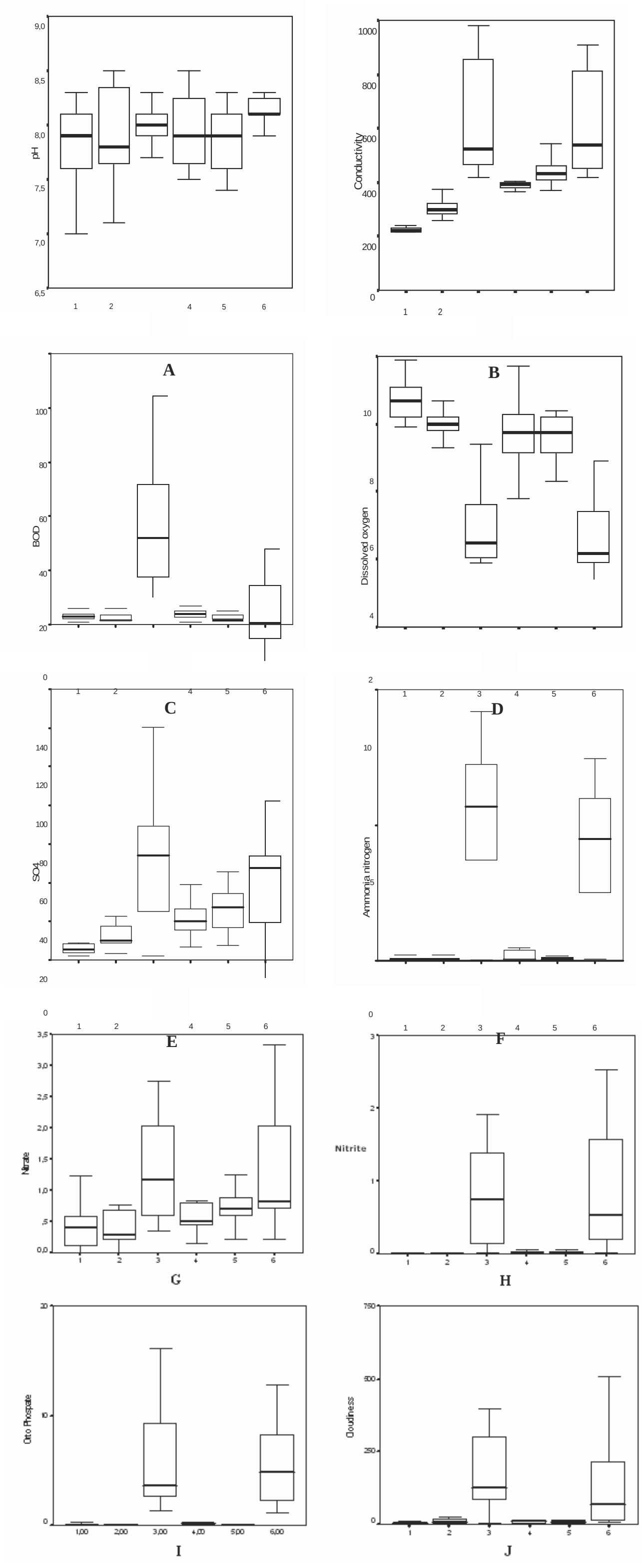

Figure 2. Physico-chemical features on sampling points in the Isparta stream and its two tributaries

Macroinvertebrates: During the study carried on between June 2003 and May 2004, from six sampling points, totally 27293 specimens were collected. These belonged to 84 taxa distributed into 6 taxonomic groups as follows: Plathelminthes (1 to Turbellaria), Mollusca (2 to Gastropoda), Annelida (1 each to Oligochaeta and

Hirudinea), Crustacea (1 to Amphipoda), Insecta (19 to Ephemeroptera, 9 to Plecoptera), 18 to Trichoptera, 16 to Diptera, 5 each to Odonata and Coleoptera, and 3 to Hemiptera), and Arachnida (2 to Acarina) (Table 1). It turned out that the Station 1 on the Eğrim Stream was the richest in organism diversity and that the most dominant group was Ephemeroptera, followed by Plecoptera. At the Station 2, the most dominant was Ephemeroptera, followed by the Diptera group. At the Station 4, the most dominant group was Ephemeroptera. At Station 5, again, Ephemeroptera was the most dominant group, followed by the Diptera.

At the Stations 3 and 6 on Isparta Stream, the most dominant taxa were Diptera and Oligochaeta. The numbers of the taxa determined are 59 taxa (Station. 1), 41 taxa (Station 2), 10 taxa (Station 3), 44 taxa (Station 4), 41 taxa (Station 5) and 15 taxa (Station 6). *The taxa of Baetis rhodani, Chirononus sp., Similium sp. and Dicronata sp.* were observed at all the stations. However, The months during which *B. rhodani'* was observed at the stations 3 and 6 were the months in which water quality levels were better, and the numbers of individuals were not very high.

Principles component analysis: Table 1 shows the macroinvertebrates found in the Isparta stream and its two tributaries. A PCA was performed in order to classify the sampling points according to their macroinvertebrate assemblages (Table 2). The first two components accounted for 75,3% of total variance. Factor 1 (47, 5 % total variance) separates the remainder from sampling points of 3 and 6. In these two sampling points, there was a significant increase of the group of species more resistant to pollution according to Meyer [17] and Metcalfe [18]. In the other sampling stations the predominant species were sensitive and less resistant to pollution (Table 2). While *Baetis sp, B. rhodoni, Rhithrogena sp., Gammarus sp., B. pavidus, Simulium sp. and Hydrophyce sp.* were the most dominant taxa at the Stations 1, 2, 4 and 5, *Chironomus sp., Tubifex tubifex and Chironumus thummi* were the most dominant at the Stations 3 and 6. Changes in the quality of water caused dominant taxa changing.

Indices: Family Biotic Index (FBI) was between oligo-saprobic and poly-saprobic levels in the stream and its two tributaries. According to average values, the Station 1 (FBI value 1,75) and the Station 4 (FBI value 1,79) were the little- polluted parts of the stream. The Stations 2 (FBI value 2,1) and the Station 5 (FBI value 1,95) were organically of average pollution. The Station 3 (FBI value 3) and the Station 6 (FBI value 2,83) were over-polluted (Figure 3.b). The lowest values were obtained at stations of 1 and 4 where the values were in the oligo-saprobic range. Number of species showed a significant decrease in stations of 3 and 6 (Figure 3.b). This trend was also reflected by the diversity indices of Margalef and Shannon-Weaver (Figure 3.c, d).

Tablo 1. List of macroinvertebrates found in the Isparta Stream and its two tributaries. Taxa with relative abundance above 5% are preceded with an asterisk.

Taksonlar	**1**	**2**	**3**	**4**	**5**	**6**
Planariidae						
Planaria sp.	+			+	+	
GASTROPODA						
Planorbidae						
Gyraulus albus MÜLLER				+		
Physidae						
Pyhsa sp.		+				+
OLİGOCHAETA						
Tubificidae						
**Tubifex tubifex* MÜLL.			+			+
HİRUDİNEA						
Erpobdellidae						
Erpobdella sp.		+	+			+
CRUSTACEA						
AMPHİPODA						
Gammaridae						
Gammarus sp.	+	+		+	+	
ARTHROPODA						
ACARİNA						
Sperchonidae						
Sperchan sp.					+	
Hydracarina						
Atractides panniculatus Viets					+	
EPHEMEROPTERA						
Baetidae						
Baetis buceratus Eaton	+	+		+		
**B. pavidus* G and	+	+		+	+	
**B. rhodani* ctet	+	+	+	+	+	+
B .lutheri Müller-Liebenau	+	+		+	+	
B .muticus Linne	+	+		+	+	
B .fuscatus Linne	+	+		+	+	
B. vernus Curt.	+	+		+	+	
**Baetis sp.*	+	+		+	+	
Leptophlebiidae						
Paraleptophlebia sp.		+			+	
Caenidae						
Caenis sp.				+	+	
Ephemerellidae						
Ephemerella ignita Poda	+					
Ephemerella sp.	+					
Heptagenidae						
Ecdyonurus sp	+	+		+	+	
Ecdyonurus dispar (Curtis)	+	+				
Heptagenia sp	+	+		+	+	
Rhithrogena semicolorata Cu t s	+					
Rhithrogena sp.	+	+		+	+	
Siphlonuridae						

Epeorus alpicola Etn.	+			+		
Epeourus sp.	+	+		+	+	
PLECOPTERA						
Chloroperlidae						
Chloroperla sp.	+	+		+	+	
Chloroperla torrentium (Pictet)	+					
Chloroperla tripunctata (Scopoli)	+					
Nemouridae						
Nemoura sp.	+	+		+	+	
**Protonemura sp.*	+	+		+	+	
Capnioneura sp.	+			+		
Leuctridae						
Leuctra sp.	+	+		+	+	
Perlidae						
Dinocras sp.	+	+				
Perla sp.	+	+				
ODONATA						
Aeshnidae						
Aeshna sp.		+		+	+	
Anax sp.	+				+	
Euphaeidae						
Epellage fatima Charpentier			+	+	+	+
Gomphidae						
Onychogomphus sp.		+		+	+	+
Libellulidae						
Libellula sp.	+					
HEMİPTERA						
Corixidae						
Gerris sp.				+		
Gerris lacustris L.					+	
Veliidae						
Velia sp.				+		
COLEOPTERA						
Elmidae						
Elmis maugetii L t ll	+	+		+	+	
Limnius sp.	+					
Gyrinidae						
Gyrinus sp.				+		
Gyrinus natator Linne				+	+	
Dytiscidae						
Agabus sp.				+		
Agabinus sp.		+		+	+	
TRİCHOPTERA						
Glossosomatidae						
Agapetus sp.	+	+		+	+	
Phryganeidae						
Agrypnia varia Fabr.	+					
Agrypnia sp.	+					
Hydropsychidae						
**Hydropsyche sp.*	+	+		+	+	+
Limnephilidae						
Limnephilus sp.	+					
Potamophylax sp.	+					
Halesus sp.	+					
Rhyacophilidae						
Rhyacophila sp.	+	+		+	+	
Sericostomatidae						
Sericostoma sp.	+					
Leptoceridae						
Ylodes sp.	+	+				
Polycentropodidae						
Polycentropus sp.	+					
Philopotamidae						
Philopotamus sp.	+					
Goera sp.	+					
Lepidostomatidae						
Lepidostoma sp.	+					
Psychomyiidae						
Psychomyia pusilla FBR.	+					
Hydroptilidae						
Oxyethira sp.		+				
Hydroptila sp.					+	
Agraylea sp.					+	
DİPTERA						
Chironomidae						
**Chironomus thummi* K.			+			+
**Chironomus sp.*	+	+	+	+	+	+
Simulidae						
**Simulium sp.*	+	+	+	+	+	+
Stratiomyidae						
Stratiomys sp.	+	+		+		
Odontomyia cincta Olivier	+					
Syrphidae						
Eristalis tenax			+			
Tabanidae						
Tabanus sp.	+	+	+		+	+
Dicronata sp.	+	+		+	+	+
Rhagionidae						
Atherix sp.	+	+			+	+
Blephariceridae						
Biblocephala sp.	+	+				
Heleidae						
Palpomyia sp.	+			+		+
Bezzia sp.		+		+		
Tipulidae						
Pedicia sp.	+			+		
Tipula sp.	+	+	+	+	+	+
Dixidae						
Dixa sp.	+			+		
Anthomyidae						
Limnophora sp.					+	

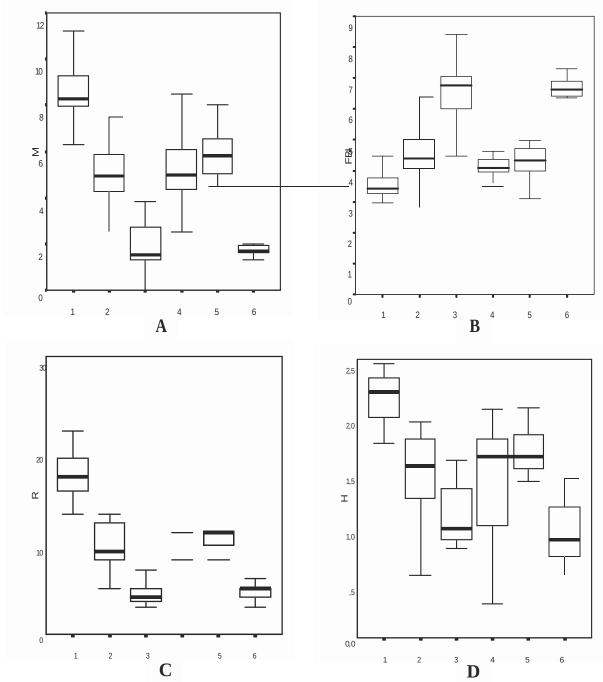

Figure 3. Representation of the A: M (Margalef's index); B: FBI (Family Biotic Index); C: R (richness species); D: H (Shannon-Weaver's index) in the Isparta stream and its two tributaries.

Tablo 2. Ordination of sampling points defined by PCA according to macroinvertebrates assembles and summary of predominant species groups in the Isparta stream and its two tributaries.

Variable	Factor 1	Factor 2	Predominant species at sampling points
Stn 1	0,568	-0,467	*Baetis s p, B . rhodoni, R hithrogena s p., Gammarus sp., B. pavidus, Simulium sp., Hydrophyce sp.*
Stn 2	0,897	-0,199	
Stn 4	0,781	-0,469	
Stn 5	0,742	-0,010	
Stn 3 0	,506 0	,771	*Chironomus sp., Tubifex tubifex, Chironumus thummi*
Stn 6	0,554	0,771	

Factor analysis Value	Eigenvalues extraction: principal component Eigenvalues %	total variance C	Cumulative Eigenval.	Cumulative %
1	2,850	47,496 2	,850 4	7,496
2	1,667	27,781 4	,517 7	5,277

The PCA of Family biotic index and diversity indices, number of species, and physico-chemical variables indicated a close relationship, on the one hand, among number of species and diversity indices and on the other hand, among Family biotic indices and BOD_5, SO_4, and conductivity (Figure 4). According to the results of the stepwise multiple regressions, the Shannon-Weaver index followed by Margalef best reflected changes in water qaulity level of the stream and its two tributaries (Table 3). According to Pearson's product-moment coefficients, the whole of physico-chemical parameters did show correlations with diversity indices (Table 4).

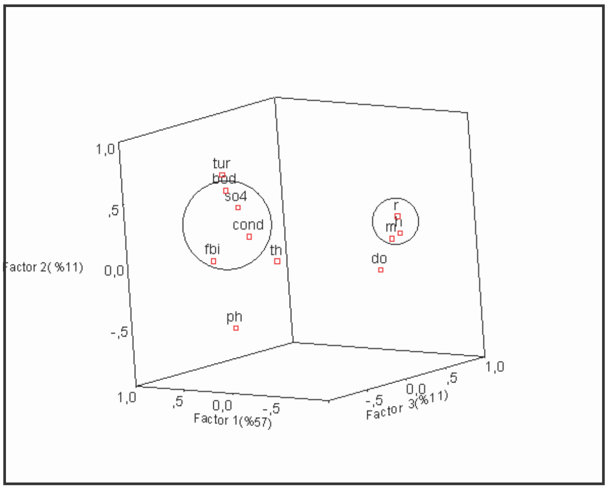

Figure 4. Representation of the three first axes of the Prenciple Companent Analysis using physico-chemical variables (bod5: Biological oxygen demand, do: Dissolved oxygen, cond: conducvity, pH, th: total hardness, tur: turbidity, SO4: sulphate, and biological indices (h: Shannon-Weaver's index, r: richness species, m: Margalef index, fbı: Family Biotic index).

Tablo 3. Result of the stepwise multiple regression analysis between richness species (R), Shannon-Weaver's index (H), Margalef index (M), Family Biotic index (FBI) and physico-chemical factors

M	ultiple R	Multiple A R	djusted R^2	F	P
R	0,749	0,560	0,537	23,794 <	000000
FBI	0,739	0,546	0,532	37,894 <	000000
M	0,766	0,587	0,572	40,491 <	000000
H	0,758	0,575	0,561	42,551 <	000000

Tablo 4. Correlation matrix between physico-chemical parametes and biological indices: R: richness species, H: Shannon-Weaver's index, M: Margalef index, and FBI: Family Biotic index (*=p<0,05; **=p<0,01; ***=p<0,001)

	R	H	M	F	BI
Conductivity -	,628**	-,532**	-,687**	,628**	
DO ,	651** ,	726**	,758**	-,683**	
BOD_5	-,495**	-,482**	-,562**	,570**	
PH -	,437**	-,296*	-,192	,351**	
Ammonium -	,512**	-,454**	-,534**	,581**	
Nitrite -	,345**	-,328**	-,389**	,443**	
Nitrate -	,401**	-,314*	-,579**	,587**	
SO_4	-,524**	-,484**	-,430***	,579***	
Total hardness	-,558**	-,409**	-,587**	,463**	
Turbidity -	,241 -	,291*	-,242	,231	

DISCUSSION and CONCLUSIONS

As a result of the researches on the Streams of Isparta and Darıören, the changes in phsyco-chemical parameters were determined, related to which the changes in species richness, FBI and diversity indices were also determined. When the polluted stations were compared with the stations determined polluted, different taxa were established dominant, too.

The highest average values of phsyco-chemical parameters of BOD_5, PO_4-P, NH_4-N, NO_3-N, SO_4, Cl and Conductivity were established at the Station 3, followed by the Station 6. The effects of the waste waters coming from Isparta were clearly observed at this station. The lowest values were seen at the Station 1, followed by the Station 4. Despite the increase, the levels of pollution at the Station 2 and 5 were determined average. Do values were seen the highest at the Station 1 and the lowest at the Station 3 (Figure 2). In the evaluation of the water quality, 3 different levels of quality were determined according to FBI. It was established that the Stations 1 and 4 were little- polluted, the Stations 2 and 5 were of average pollution and the Stations 3 and 6 were over-polluted (Figure3-b).

Family biotic index indicated good water quality in sampling point 1. That is because sampling point 1 is the closest to the source area and no wastewater is discharged into it. At this station, 64 taxa were determined. The most dominant taxa were established to be Ephemeroptera and Plecoptera successively. The biggest number of individuals in Ephemeroptera was of *Baetis sp. and Protonemura sp.* in the taxon of Plecoptera. According to Meyer [17], *Baetis species* takes places in oligosabrop zones. The highest Family Biotic index values were recorded in the 3rd and 6th sampling points because of wastewater discharge from Isparta. At the station III, 10 taxa were determined, most of which belong to Diptera. However, *Chironomus thummi* and *Chironomus sp.* were the most dominant taxa in the Diptera. At this station, *Baetis rhodani* was observed to be dominant only in May. The dominance results from the recovery of water quality, and the lowest values of NH_4-N, NO_3-N, PO_4-P, Cl and EC were established in this month. Inorganic nutrients do not have a direct impact on benthic invertebrates, expect for the worst cases of eutrophication when toxic concentrations of ammonia and very low levels of dissolved oxygen occur [3]. At the station 6, Baetis rhodani was observed to be low in general but increased only in January. At the stations of 2, 4 and 5, the most dominant taxon was Baetis sp. of Ephemeroptera. Predominant taxa was Baetis sp, B. rhodoni, Rhithrogena sp., Gammarus sp., B. pavidus, Simulium sp. and Hydrophyce sp. sampling satations 1, 2, 4 and 5 while predominant taxa was Chironomus sp., Tubifex tubifex and Chironumus thummi sampling station 3 and 6 (Table 2).

The changes in physico-chemical parameters were reflected by FBI well, and a strong relation between them was determined (Table 4). The taxa determined at the stations, too, reflect these changes clearly. A great majority of the taxa determined at the Stations 1, 2, 4 and 5 were not seen at the Stations 3 and 6, and the dominant taxa determined at these stations could not be established at the other stations (Table 1).

Benthic macroinvertebrate species are differentially sensitive to many biotic and abiotic factors in their environment. Consequently, macroinvertebrate community structure has commonly been used as an indicator of the condition of an aquatic system [2, 19, 20]. Macroinvertebrate data are used in the biological monitoring of water quality and their relative advantages over other groups of aquatic organisms for this purpose are well documented. Species richness is an integrative descriptor of the community, as it is influenced by a large number of natural environmental factors as well as antropogenic disturbances [6]. This consideration is applicable to the benthic macroinvertebrates in the Darıören and Isparta Streams where the PCA ordinate sampling points according to a pollution gradient. The PCA of Family biotic index and diversity indices, number of species, and physico-chemical variables indicated a close relationship, on the one hand, among number of species and diversity indices and on the other hand, among Family biotic indices and BOD5 , SO4, and conductivity (Figure 4). Before establishing relationships between the diversity values and the level of pollution it is essential to identify the real nature of the stress, that is, the main causes influencing the diversity value. This is also true for any biotic index [21].

In this study, the number of species is the highest at station 1 (Figure 3-c) and this is also reflected by Margalef and Shannon-Weaver indices and FBI (Figure 3-a-b-d). As the amount of pollution is higher at stations 3 and 6, the number of species is fewer in these stations compared to the others. Sampling points 1 and 4 was good and 2 and 5 was average water quality level (Figure 3-b). Diversity indices have been widely used for many purposes [e.g. 22, 2, 23, 18]; however, they have also received much criticism about not being community parameters. They are a confusion of independent and unrelated parameters: taxonomic richness and the abundances of individual taxa. Hawkes [24] feels that diversity indices are good for indicating physical and toxic pollution which stress most species in a community without encouraging replacement species. He warns that high diversity does indicate good quality water but low diversity may not necessarily indicate low quality. In a research by Kalyoncu et al. [25] in the Aksu River, it has been explained that Margalef Diversity indices and Belgium Biotic indices support each other and that they reflect the pollution changes in the river. Our results show that low diversity values indicate low quality of water and that high diversity values indicate good quality of water in Darıören and Isparta streams (Figure 3-a-b-d).

Of the community indices, the reduction in similarity for all indices was statistically significant in response to chronic thermal stress, but only Margalef's index provided a statistically significant reduction in similarity in response to the acid impact[6]. Except for seasonal comparisons, unimpacted years or sites had high similarities, but these overlapped with values under impacted conditions for Simpson's and Shannon's Index. The FBI showed lower similarities under impacted conditions than under unimpacted conditions, and reductions under impacted conditions were statistically significant [6]. However, in our research, the FBI and diversity indices on the Isparta and Darıören Streams reflect the changes in the physico-chemical structure in the best way and support each other. The highest FBI values were obtained at the Stations 3 and 6, where the lowest diversity values were also determined. Again, the fewest taxa were determined at these stations as well. The lowest FBI values were obtained at the Station 1, where the highest diversity values were also determined. Again, the highest number of taxa was determined at this station as well (Figure 2). In addition, species richness, diversity index and FBI were in harmony with the changes in the physico-chemical parameters (Table 4).

In Darıören and Isparta streams, changes in water quality were better reflected by diversity indices and FBI. This fluvial system is affected by a complex of contamination factors in relation with discharges of organic and inorganic wastes such as inadequately treated sewage. Organic and inorganic micro pollutants affect both biomass and diversity of aquatic communities. The variation of Shannon diversity revealed a higher dependence on evenness component than taxa richness in the upstream and downstream of La Tordea stream [20]. The biotic index and score systems are better for assessing organic pollution and eutrafication but poor for assessing toxic and physical pollution. Therefore, to obtain a fair overall assessment of the quality of a river, both methods are essential and need to be combined with alternative methods of evaluating biotal response [26]. Evaluating the change of water quality, FBI and diversity indices support each other, reflect very well the changes in the aquatic system and give more information about the aquatic ecosystem.

Despite many researches done in Europe, there are only a few based on bentic macroinvertebrates for monitoring rivers in Turkey [27, 28, 29, 30, 25]. In this study, for the first time, the diversity indices and Family Biotic index were applied in Turkey. It can be said that, according to the results obtained, the use of FBI and diversity indices can produce reliable results Southwest Region streams in Turkey.

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