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Diversity of Invertebrate Fauna in Littoral of Shallow Musaözü Dam Lake in Comparison with Environmental Parameters

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Abstract

Musaözü Dam Lake (MDL), located on Mollaoğlu River, is the main irrigation water resource of Eskisehir, Turkey. The river and the reservoir are both under the threat of pollution primarily originated from several domestic and industrial point sources and land-based diffuse. The numerical and proportional distributions of benthic invertebrates in MDL were surveyed seasonally from January 2003 to December 2003 at six different stations. According to the results benthic invertebrate fauna consisted of Oligochaeta (42,5 %), Chironomidae larvae (30,5 %) and the varia (27 %). By evaluating the data via a Shannon-Wiener index it was found that the MDL had an index of 2,32 richness at 2nd station (inlet) and July had the widest diversity; while 4th station and January had the poorest. According to Bray-Curtis similarity index, the 5th and the 6th stations were found to be very similar to each other; while 1st and 2nd stations (outlet and inlet) were observed to be the most different from all of the other stations in terms of the dynamics of the benthic fauna. Also some physicochemical parameters and some microbiological parameters of the water were analyzed. The relationships between the dynamics of organisms and environmental parameters were supported by Pearson Correlation Index and Canonical Correspond Analysis. We found that the Dam Lake water is polluted with Cu, Cr, Ni and partly with Fe and Mn; in addition pH level of Dam Lake water is higher than inlet water. High pH and second quality levels of NO_3-N, and third quality levels of NO_2-N, third quality levels of Cu, Cr, Ni and, 2,32 species richness showed that similar studies should be repeated periodically in MDL so as to predict the future of the Dam Lake.

Key words: Benthic invertebrates, Musaözü dam lake, Oligochaeta, Chironomidae, Turkey.

INTRODUCTION

Benthic invertebrates play a key role in the littoral zone of lakes. Benthic invertebrates community composition is closely linked to habitat conditions and many of them may serve as biological indicators of various environmental stresses on aquatic ecosystems, such as inorganic contaminants [1]. Although human activities have substantially modified (and generally, degraded) a wide variety of habitats worldwide, some habitat types are especially vulnerable to anthropogenic disturbance. The increasing levels of anthropogenic disturbance mean that we need detailed ecological knowledge of the zoobenthic fauna of freshwater systems if these systems are to be managed effectively [2]. It's known that, zoobenthos is defined as a group of invertebrates, whose existence for the greater part of their life cycle is related to bottom substrates of water bodies. Studies of qualitative characteristics of zoobenthos (fish food base) are of great importance. Bottom communities of most freshwater bodies are represented by two major groups: chironomid larvae and oligochaetes. Oligochaetes permanently live on the bottom, whereas chironomids, being larval forms of insects, spend only a part of their life cycle on the bottom of water bodies. Many species of this group manifest a distinct response to the presence of different pollutants in the water mass and bottom sediments, thus serving as indicators of the degree of pollution of the water body [3]. In addition, certain species of Oligochaeta and Chironomidae are abundant in organically polluted waters because of lack of competition and an abundant food supply coupled with a tolerance to reduce oxygen condition [4] and they are considered a promising indicator of water quality because of their ubiquity and abundance in aquatic ecosystems [5, 6].

To date, there has been no study related to benthic invertebrates and environmental parameters of Musaözü Dam Lake (MDL). This study is aimed at investigating the qualitative and quantitative characteristics of benthic invertebrates in the MDL. In this study, scales of distribution and relationships with environmental variables of benthic fauna were examined in MDL. Data have also been used to identify correlative relationships between physicochemical features and the dynamics of bentic fauna.

MATERIALS AND METHODS

Study Area: Musaözü Dam Lake is a reservoir that supplies irrigation to Eskişehir (Turkey) (irrigation area 400 ha.). The volume and surface area of the reservoir is 244 000 m^3 and 0.43 km^2 respectively. Mollaoğlu is the main river that carries water to MDR (Fig. 1).

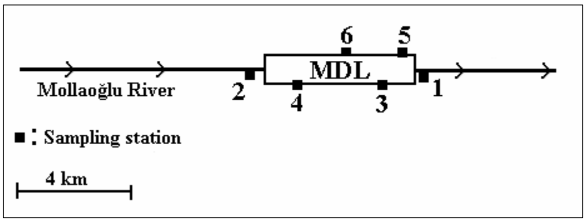


Figure 1. Sampling stations in Muasaözü Dam Lake.

Sampling: Benthos samples collected from January 2003 to December 2003. Six stations were selected from MDL (Fig. 1); first and second stations were downstream and upstream respectively; 3th-6th stations were belonging to the dam lake. Samples were taken in two replicas with a hand net (with coverage of 0.025 m^2). Samples of benthic invertebrates were fixed on site with 4 % formaldehyde. After the samples had been sorted, oligochetes and chironomids larvae were prepared for identification by either mounting permanently on slides using Canada balsam or prepared temporary mounts using a glycerin-water (1:5) solution. Where possible, benthic invertebrates were identified to species level (especially Chironomidae and Oligochaeta), nevertheless some taxa such as Ostracoda, Copepoda and most Diptera larvae were left at a higher taxonomic level. For taxonomical identification of the Oligochaeta specimens, publications by Sperber [7], Brinkhurst and Jamieson [4], Brinkhurst and Wetzel [8]; for Chironomidae samples Şahin [9], Epler [10]; for other taxa Bouchard [11], Elliott, et al. [12] and Pennak [13] were used.

At each station 21 physical, chemical and biological variables were determined (Table 1). Water temperature, hydrogen ion concentration (as pH), dissolve oxygen (by use the WQC TOA-22 mark) were measured in the field. Biological Oxygen Demand (BOD) was measured by using the Enotek mark oxygenmeter. Two replicates of water samples from each station were stored in polyethylene bottles (1000 ml). The

Table 1. The highest and lowest values of the measured environmental in MDL (numbers in the parentheses are indicated the average value).

Stations	1	2	3	4	5	6
pH	6.7-8.1	8.1-8,2	7,5-8,9	8,4-8,9	7,4-8,7	7,8-8,7
	(7,5)	(8.1)	(8,2)	(8,6)	(7,9)	(8,3)
Temp.	4-20,1	4,9-19,7	4,3-25,5	4,2-24,1	4,2-23,5	4,8-23,9
	(10,5)	(11,2)	(13,3)	(12,8)	(12,6)	(13,2)
DO	2-13,3	7,7-13	9,5-12,4	7,6-12,2	7,8-13	13,4-8,05
	(8,7)	(11,2)	(11,4)	(10,3)	(10,7)	(11,2)
BOD	1-9	0-4	0-3	1-3	1-4	1-4
	(3,7)	(3,7)	(1)	(1,7)	(2,3)	(2,3)
SO_4	0,005-0,023	0,031-0,191	0-0,084	0-0,054	0-0,046	227-37
	(0,016)	(0,087)	(0,047)	(0,024)	(0,017)	(116)
NH_4-N	0,015-0,718	0-0,001	0-0,043	0-0,010	0-0,013	0-0,009
	(0,267)	(0,026)	(0,003)	(0,003)	(0,004)	(0,003)
NO_2-N	0,007-0,029	0,004-0,029	0,011-0,026	0,007-0,029	0,01-0,026	0,009-0,027
	(0,019)	(0,019)	(0,019)	(0,02)	(0,019)	(0,021)
NO_3-N	0,58-1,63	0,41-2,45	3,38-0,5	1,5-1,6	0,75-2,19	0,77-1,74
	(1,26)	(1,66)	(1,94)	(1,58)	(1,66)	(1,37)
PO^{-3}_4–P	0,019-0,05	0,03-0,19	0-0,057	0-0,054	0-0,005	0-0,112
	(0,031)	(0,087)	(0,024)	(0,024)	(0,016)	(0,082)
Cu	32-50	122-282	19-108	20-84	0-52	0-98
	(42)	(196)	(72)	(50,7)	(30,7)	(60)
Cr^{+6}	0-191	0-297	0-127	0-361	3-79	0-482
	(88,3)	(103,7)	(57,3)	(131)	(28,3)	(163,3)
Ni	0-192	0-330	0-52	0-278	0-128	0-140
	(88)	(148)	(65,7)	(120,7)	(42,7)	(46,7)
Zn	11-337	15-382	0-577	0-526	0-477	17-728
	(181,3)	(225,7)	(215,3)	(211,7)	(199)	(260,3)
CN	2-13	2-7	0-4	0-8	0-9	0-9
	(6)	(5)	(2,3)	(3,3)	(3,3)	(3,3)
Cl_2	58-116	92-232	52-22	36-106	34-130	48-176
	(82,7)	(147,3)	(114)	(70,7)	(69,3)	(94)
Fe	0-178	0-561	0-86	0-242	0-49	0-72
	(74,7)	(233,7)	(32,7)	(100)	(17,3)	(24)
Mn	68-86	68-174	103-204	0-144	114-140	100-148
	(75,3)	(128,7)	(145)	(48,7)	(128)	(128)
B	2-50	4-50	0-2	3-50	0-16	0-26
	(32)	(18)	(1,3)	(21,7)	(9)	(11)
Al	0,007-0,055	0-0,002	0-0,001	0-0.001	0-0,057	0-1
	(0,024)	(0,038)	(0,027)	(0)	(0,020)	(0,334)
Veg.	++	++	+	-	-	+
T.c.	0-930	430-4600	200-4600	0-430	0-90	0-90
	(323)	(2377)	(1910)	(157)	(60)	(43)
F.c.	0-230	0-2400	0-2400	-	-	-
	(77)	(1577)	(830)			
H'	2,99	3,19	2,90	2,46	2,63	2,78
Evennes	0,84	0,87	0,93	0,77	0,86	0,88

(Abbreviation: T.c:Total coliform; F.c: Fekal coliform; Veg.: Vegetation; *H'*: Shannon Wiener diversity; Measurement for DO, BOD, SO_4, NH_4N, NO_2N, NO_3N, PO^{-3}_4–P= mg l^{-1}; for heavy metal= µg l^{-1}; for temperature= °C; for Total coliform and Fecal coliform: MPN (most probable number)/100 ml).

chemical oxygen demand (COD), NH_4-N, NO_{2-}N/l, NO_{3-}N, $PO^{-}_{3\,4}$-P, some heavy metals (Cu, Cr, Ni, Zn, CN, Fe, Mn, B and Al), total and fecal coliform were all determined in accordance with the standard method procedures [14]. The water in the polyethylene bottles were preserved with 2ml of concentrated hydrochloric acid (pH<2.0) and brought back to the laboratory. The water samples were kept in a refrigerator at a temperature below 4 °C and were analyzed in 24 hours. Fecal coliforms (Fc) and *Escherichia coli* were enumerated using the most probable number technique (MPN) (Table 1). The highest and lowest values of the measured physical, chemical and microbiological parameters of six sampling sites of MDL during the study period are given in Table 1.

First, Log Base 10 was applied to the data and Shannon-Wiener species diversity index was then applied to analyze taxa statistically. Relationship between Oligochaeta and Chironomidae species and selected environmental variables (such as vegetation, temperature, dissolve oxygen and biological oxygen demand) were evaluated by Canonical Correspondce Analysis (CCA) using the CANOCO program for Windows [15, 16]. Two temperature (10.5 °C -12.5 °C= I; 12,6 °C- 14 °C= II) , three DO (8 mg l^{-1}-9 mg l^{-1}= I; 9.1 mg l^{-1}- 10 mg l^{-1}= II; 10.1 mg l^{-1}- 11.5 mg l^{-1}= III), BOD (1 mg l^{-1}-1.8 mg l^{-1}= I; 1.9 mg l^{-1}-2.4 mg l^{-1}= II; 2.5 mg l^{-1}-3.8 mg l^{-1}= III) and vegetation (absent:1; moderate:2; dense:3) classes were treated as supplementary variables in the analysis. Also the Pearson Correlation index was used to determine whether there were any correlations between the environmental parameters and number of individuals (for only Oligochaeta and Chironomidae species) or not.

RESULTS

A total of 56 invertebrate taxa were recorded [only Oligochaeta (Annelida) and Chironomidae (Diptera) samples were identified to the genus or species level] from the MDL (Table 2). Diversity and abundance of benthic invertebrates of MDL to the stations was shown in Fig. 2. As can be seen from Table 2 and Fig. 2, stations 1 and 2 were the richest in terms of taxa diversity. Thirty-eight taxa were collected from station 1, 39 from station 2, 31 from station 3, 23 from station 4, from station 5, 23 and 25 from station 6. The most diverse group

Table 2. Taxonomical list of benthic invertebrates of Musaözü Dam Lake and their proportional (as %).

	Stations / Taxa	1	2	3	4	5	6	Average
1	**Nematoda**	4,4	6,9	5,3	4,7	5,3	4,2	5,1
	Mollusca							
2	Gastropoda	7,1	3,1	7,9	5,1	4,8	6,5	5,8
3	Bivalvia	2,3	-	-	-	-	-	0,4
	Annelida							
	Oligochaeta							
4	*Lumbriculus variegates* (Müller, 1774)	-	0,5	-	-	-	0,4	0,1
5	*Tubifex tubifex* (Müller, 1774)	1,8	3,6	2,9	1,3	4,7	6,4	3,4
6	*Limnodrilus hoffmeisteri* Claparede,1862	2,7	4,7	3,3	10,0	5,5	4,8	5,2
7	*Limnodrilus udekemianus* Claparede,1862	-	2,0	-	-	-	-	0,3
8	*Psammoryctides albicola* (Michaelsen, 1901)	8,2	8,6	7,3	10,7	12,3	7,9	9,2
9	*Potamothrix hammoniensis* (Michaelsen, 1901)	4,5	4,8	4,7	7,3	-	5,4	4,5
10	*Potamothrix bavaricus* (Öschmann, 1913)	-	-	-	-	3,4	-	0,6
11	*Paranais fricii* Hrabe,1941	-	0,5	0,7	-	-	-	0,2
12	*Ophidonais serpentina* (Müller, 1774)	-	-	2,9	-	-	-	0,5
13	*Nais communis* Piguet,1906	2,1	3,6	2,5	2,5	11,6	4,2	4,4
14	*Nais variabilis* Piguet,1906	3,7	6,4	-	-	-	1,6	1,9
15	*Nais pardalis* Piguet,1906	1,9	-	-	-	-	-	0,3
16	*Nais elinguis* Piguet,1906	0,5	-	-	8,1	-	-	1,4
17	*Nais barbata* Müller, 1773	2,9	-	-	-	-	-	0,5
18	*Nais bretscheri* Michaelsen, 1899	2,1	-	-	-	-	-	0,4
19	*Stylaria lacustris* (Linnaeus, 1767)	4,0	9,0	6,9	3,8	5,1	4,3	5,5
20	*Dero digitata* (Müller, 1773)	3,0	2,1	1,2	1,3	3,1	2,7	2,2
21	*Aulophorus furcatus* (Müller, 1774),	-	0,2	-	-	-	-	0,029
22	*Pristinella jenkinae* (Stephenson , 1931)	5	1,9	0,5	2,5	-	1,9	2,0
	Average Oligochaeta	42,5	47,6	32,8	47,3	45,7	39,5	42,5
23	Hirudinae	7,2	-	0,26	2,6	1,5	0,4	2,0
	Crustacea							
24	Amphipoda	1,4	-	-	-	-	-	0,2
25	Isopoda	5,7	1,3	-	-	2,0	-	1,5
26	Ostracoda	3,6	-	8,7	1,9	9,2	5,1	4,7
	Insecta							
27	Plecoptera	-	0,4	-	-	-	-	0,1
28	Ephemeroptera	2,5	2,4	0,9	-	-	-	1,0
29	Trichoptera	0,9	0,1	-	-	-	-	0,2
30	Hemiptera	-	1,2	0,7	-	1,3	-	0,5
31	Coleoptera	5,8	2,9	1,5	-	0,3	4,2	2,4
	Diptera							
32	Ceratopoganiidae	2,9	1,5	1,7	-	-	1,4	1,2
	Chironomidae							

33	*Clinotanypus pinquis* (Loew,	0,2	-	-	-	-	-	0,029
34	*Procladius* (*Psilotanypus*)sp.	2,4	4,1	5,7	5,7	4,4	5,9	4,7
35	*Tanypus punctipennis* Meigen, 1818	-	1,8	3,6	1,9	4,9	6,8	3,2
36	*Prodiamesa olivecea* (Meigen, 1818)	-	1,0	0,3	-	-	-	0,2
37	*Cricotopus* (*C.*) *tremulus* (Linnaeus, 1756)	0,2	0,6	-	-	-	-	0,1
38	*Nanocladius rectinervis* (Keiffer, 1911)	-	-	-	-	0,8	-	0,1
39	*Nanocladius bicolor* (Zetterstedt , 1838)	0,3	3,0	0,9	4,2	7,1	4,4	3,3
40	*Eukiefferiella brevicalcar* (Keiffer, 1911)	2,5	1,1	-	-	-	1,4	0,8
41	*Chironomus riparus* K., 1911	-	0,5	-	-	-	-	0,1
42	*C. (Camptoch.) tentans* Fabricius, 1805	-	1,5	-	-	-	-	0,3
43	*Cryptochironomus defectus* (Keiffer, 1913)	2,7	3,3	5,3	2,2	-	-	2,2
44	*Pentapedilium exsectum* (Keiffer, 1916)	0,7	-	-	-	-	-	0,1
45	*Polypedilum nubeculosum* (Meigen, 1804)	2,0	0,4	1,1	1,4	1,3	-	1,0
46	*Polypedilum pedestre* (Meigen, 1830)	0,5	-	-	-	-	-	0,1
47	*Polypedilum scalaenum* (Schrank, 1803)	1,6	2,2	1,7	-	-	1,9	1,2
48	*Stictochironomus yalvacii* Şahin, 1971	2,6	1,5	1,3	7,5	2,5	-	2,6
49	*Dicrotendipes tritomus* (Kieffer, 1916)	-	3,0	4,7	2,1	-	2,9	2,1
50	*Endochironomus tendans* (Fabricius, 1775)	-	0,2	-	-	-	-	0,029
51	*Cladotanytarsus mancus* (Walker, 1856)		0,5	6,2	10,6	3,8	8,7	5,0
52	*Paratanytarsus lauterborni* (Kieffer, 1909)	2,2	-	5,8	0,4	6,2	4,9	3,2
	Average Chironomidae	17,9	24,7	36,6	36,0	30,9	36,9	30,5
53	Culicidae	1,9	-	1,6	-	-	2,2	0,9
54	Simuliidae	0,7	-	-	-	-	-	0,1
55	Tabanidae	-	0,7	0,3	-	0,3	-	0,2
56	Chaoboridae	-	0,2	-	-	-	-	0,02
	Number of taxa	38	39	31	22	23	25	100

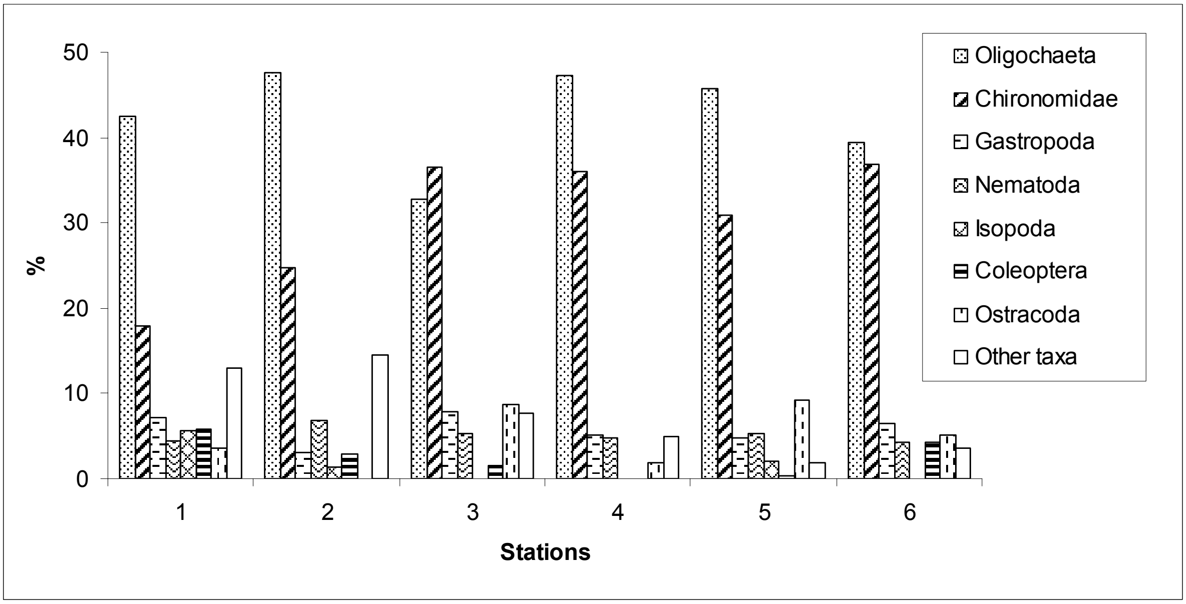


Figure 2. Diversity and distributions of benthic invertebrates in the MDL to the stations.

was Chironomidae (20 species), followed by Oligochaeta (19 species). There are differences both in the number of taxa and in the number of individuals between the stations of dam lake (stations 3, 4, 5 and 6) and inlet-outlet stations (stations 2 and 1 respectively) (Table 2 and Fig. 2). The greater part of benthic invertebrate was represented by chironomid larvae and oligochaetes. Chironomid larvae dominated in terms of species diversity (20 species) and Oligochaeta were represented by 19 species while oligochaetes dominated in terms of number of individual (or 42,5 % of all the benthos taxa found in the dam lake).

Chironomidae larvae group had 20 taxa and 30,5 % abundancy. *Cladotanytarsus mancus* belonging to this group was found to have the highest abundance (5 %) and it was followed by *Procladius* (*Psilotanypus*) sp. (4,7 %) and *Nanocladius bicolor* (3,3 %). Number of taxa belonging to Chironomidae larvae was the highest at 2nd station in July while it was the lowest at 4th and 5th station in January.

It was found that Oligochaeta group had 19 taxa and the highest abundance with 47,6 %. *Psammoryctides albicola* belonging to this group was found to have the highest abundance (9,2 %) and it was followed by *Stylaria lacustris* (5,5 %) and *Limnodrilus hoffmeisteri* (5,2 %). Number of taxa belonging to Oligochaeta was the highest at 2nd station in July while it was the lowest at 5th station in January and July. In addition, *Nais bretscheri, Nais barbata* and *Nais pardalis* were found at only one station (first station, namely outlet) while *Aulophorus furcatus* was found at only inlet (station 2).

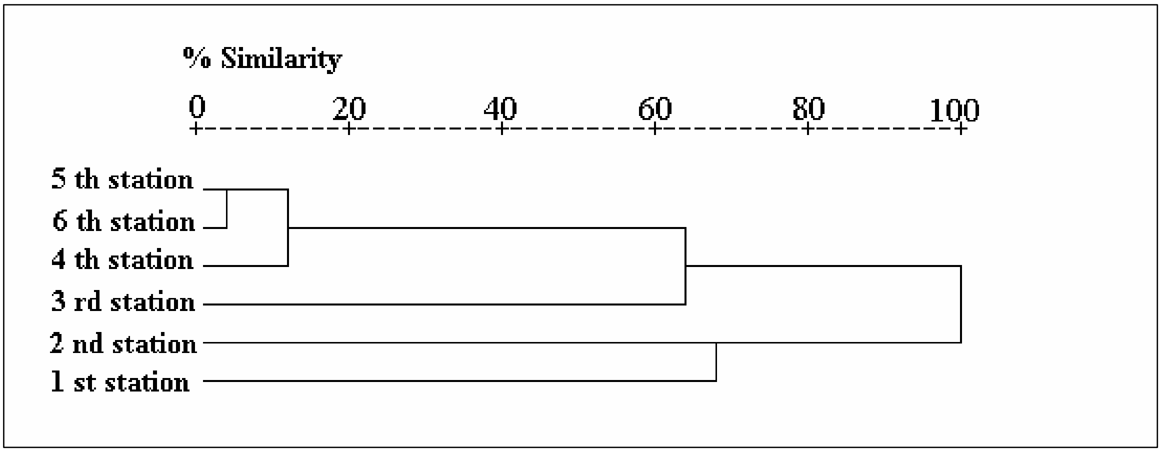


Figure 3. The dendrogram of similarity of stations in MDL in respect of benthic invertebrates.

It was found that the other invertebrate groups had 17 taxa. Gastropoda belonging to this group was found to have the highest abundance (5,8 %) and it was followed by Nematoda (5,1 %) and Ostracoda (4,7 %). As can be seen in Table 2, the numbers of benthic invertebrates taxa recorded in the stations could be ordered as 2>1>3>6>5>4. In addition, in the present study, the taxa; Bivalvia, Amphipoda, Isopoda, Plecoptera, Ephemeroptera, Trichoptera, Simuliidae, Chaoboridae, some species of Chironomidae (*Clinotanypus pinguis, Cricotopus (Cricotopus) tremulus, Eukiefferiella brevicalcar, Polypedilium*

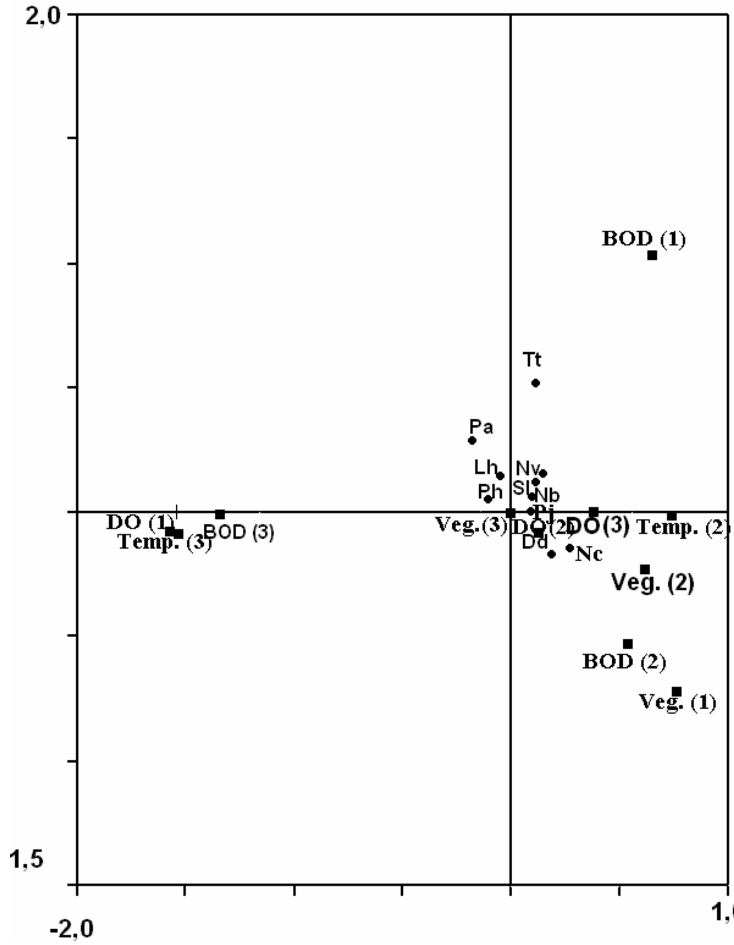


Figure 4a. Canonical correspondence analyses of selected water parameters with selected Oligochaeta species in MDL. Closed circles represent of species, squares represent of environmental parameters (Ph=*Potamothrix hammoniensis*; Lh=*Limnodrilus hoffmeisteri*, Pa=*Psammoryctides albicola*, Tt=*Tubifex tubifex*, Nv=*Nais variabilis*, Sl=*Stylaria lacustris*, Nb=*Nais bretscheri*, Pj=*Pristinella jenkinae*, Dd=*Dero digitata*, Nc=*Nais communis*).

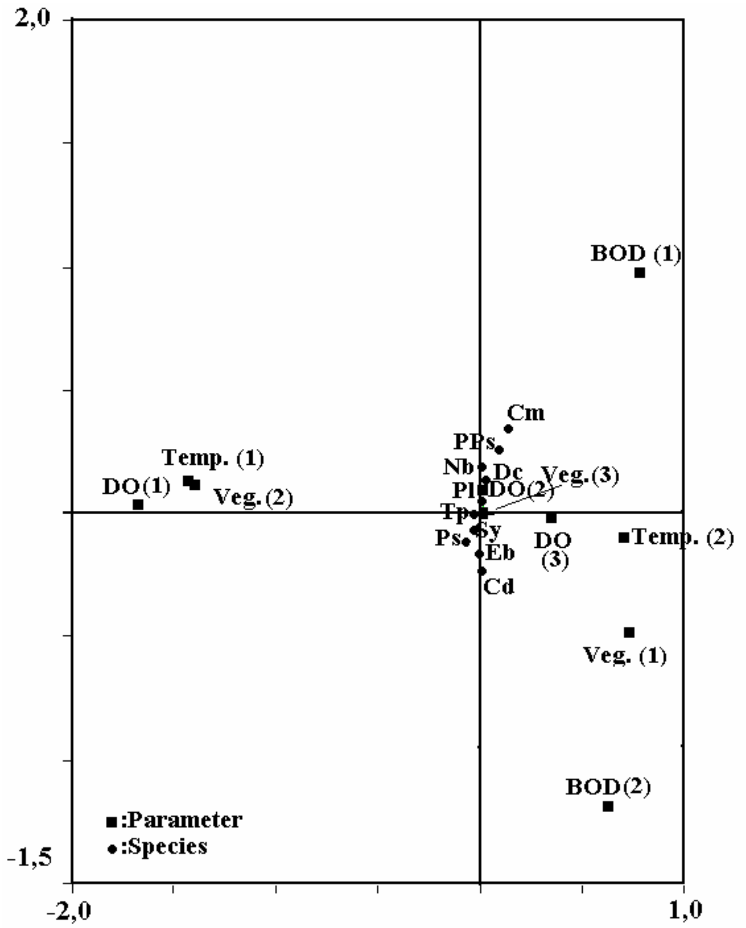


Figure 4b. Canonical correspondence analyses of selected water parameters with selected Chironomidae species in MDL (Cd: *Cryptochironomus defectus*, Cm: *Cladotanytarsus mancus*, Dt: *Dicrotendipes tritomus*, Eb: *Eukiefferiella brevicalcar*, Nb: *Nanocladius bicolor*, Ps: *Polypedilum scalaenum*, PPs: *Procladius* (*Psilotanypus*)sp., Tp: *Tanypus punctipennis*).

pedestre, Pentapedilium exsectum, Endochironomus tentans, and some Oligochaeta species (*Nais bretscheri, Nais barbata, Nais pardalis* and *Aulophorus furcatus*) were found in inlet or outlet.

According to Shannon-Wiener index, the species diversity in MDL was found as 2,32 at average and, 2nd station in July were found to have the widest diversity while 4th station in January to have the poorest diversity (Table 2). According to Bray-Curtis similarity index (Fig. 3), 5st and 6nd stations were found to be very similar to each other while 1st and 2nd stations (outlet and inlet) were found to be the most different from all the other station for the dynamics of the benthic invertebrate fauna (both the numbers and species).

Canonical correspondence analysis (CCA) concerned four environmental variables (vegetation, temperature, dissolve oxygen and biological oxygen demand) and selected oligochaeta-chironomidae species which were shown common distribution or high abundance. Results of canonical correspondence analysis for oligochaete and chironomid species are shown in figs 4a and 4b. In these analyses, the environmental and taxa variables are combined into a composite. Closed circles represent taxa, squares represent environmental variables. As can be seen from Fig. 4a relationship was recorded between the abundance of *Potamothrix hammoniensis* (Ph), *Limnodrilus hoffmeisteri* (Lh) and *Psammoryctides albicola* (Pa) and third level of temperature and BOD. In addition, significant relationship was recorded between third level of DO and *Nais variabilis* (Nv) and *Pristinella jenkinae* (Pj); between second level of temperature and *Pristinella jenkinae* respectively.

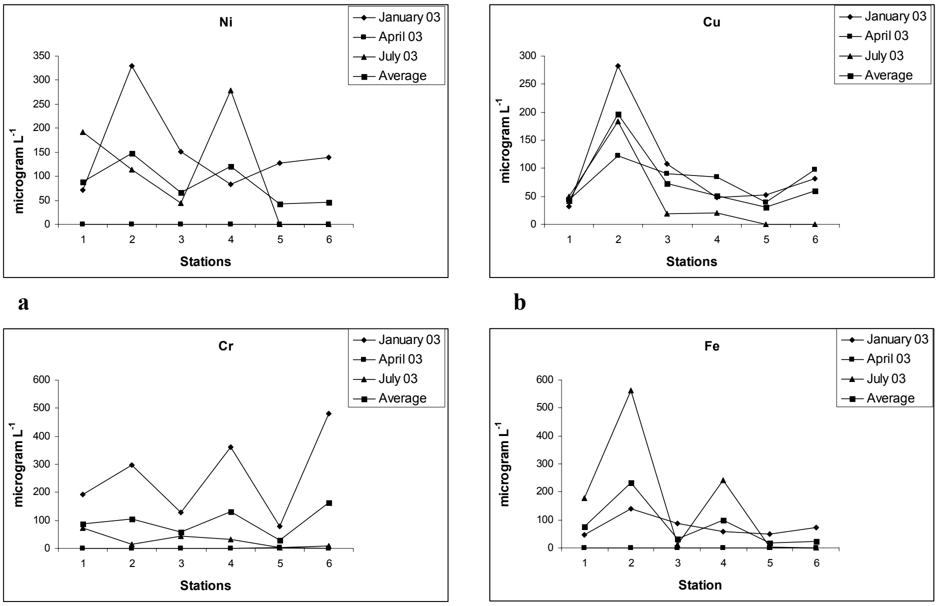
Correlations of Oligochaeta and Chironomidae species, which were shown common distribution or high abundance, with environmental parameters of MDL water are presented in Table 3. Normal seasonal variations of temperature were observed in all stations during the study period. *Potamothrix hammoniensis* and *Tanypus punctipennis* showed positive correlations to the water temperature whereas *Pristinella jenkinae* showed negative correlations. The measurements of DO in the MDL showed minimum values in July at station 1, the maximum value is indicated at station 1 (in January). Low DO values at stations 1 in July can be related to high temperature and location of the station (outlet). It was found that the abundance of Oligochaeta species *Nais variabilis* and Chironomid species *Tanypus punctipennis* showed a positive correlation to the DO level of the water while *Aulophorus furcatus* and *Polypedilum pedestre* showed a negative correlation. Furthermore, abundance of these two species showed that significant positive correlation with the NH_4-N level of the water while *Tanypus punctipennis* showed significant negative correlation (Table 3). On the other hand, the relations between the average number of Oligochaeta and Chironomidae species and the other environmental parameters were found not to be statistically significant.

It was determined that MDL water was polluted with Cu, Cr, Ni and partly with Fe and Mn (Table 1 and Fig. 5). Average and levels of Cu, Cr, Ni and Fe are shown in Fig. 5. According to the values established for polluting elements in surface water by the Turkish Government [17] the concentrations of heavy metal (especially Cu, Cr, Ni and partially Fe and Mn) in the MDL' water surpass the upper limits (upper limits indicated in Fig. 5e). The metal concentrations in the MDL water were found as in the range of 0-330 μgl^{-1} for Ni (at station 2 in January 03), for Cu 0-282 μgl^{-1} (at station 2 in January 03), for Cr, 0-482 μgl^{-1} (at station 6 in January 03) for Fe, 0-561 μgl^{-1} (at station 2 in January 03). The highest concentrations of Ni, Cu, Mn, and Fe were found at Site 2, while the highest concentration of Cr was found at station 6 (482 μgl^{-1} in January 03).

Table 3. Pearson's correlation coefficients between abundance of selected Oligochaeta and Chironomidae species and examined environmental parameters of MDL.

	Oligochaeta species					
Parameters	*Potamothrix hammoniensis*	*Limnodrilus hoffmeisteri*	*Psammoryctides albicola*	*Nais variabilis*	*Pristinella jenkinae*	*Aulophorus furcatus*
Temp.	,803(*)	,745	,813(*)	-,776	-,908(*)	-,754
DO	-,113	,141	-,289	,828(*)	-,793	-,916(*)
BOD	,851(*)	,951(**)	,642	-,100	,797	,567
NO_3N	,413	,348	,095	-,167	-,630	-,649
NO_2N	,308	,221	-,802	-,362	-,253	-,293
NH_4N	,309	,255	,477	,329	,898(*)	,996(**)
Cu	,543	,604	,619	,844(*)	,220	-,268
Ni	,693	,905(*)	,643	,711	,445	,029
Fe	,599	,793	,723	,883(*)	,440	-,033
Mn	-,206	-,350	,006	,075	-,402	-,440
B	,346	,222	,403	,441	,837(*)	,745
Al	-,147	-,539	-,623	-,149	-,142	-,191
Cl	,604	,375	,567	,731	,189	-,223
Tcol	,608	,487	,655	,603	,097	-,229
F. col	,564	,540	,691	,732	,142	-,252
pH	,081	,470	-,538	-,344	-,629	-,786
	Chironomidae species					
	Endochironomus tendans	*Polypedilim pedestre*	*Tanypus punctipennis*	*Polypedilim scalaenum*	*Chironomus (Camptoch.) tentans*	*Cricotopus (Cricotopus) tremulus*
Temp.	,455	-,754	,872(*)	,591	-,455	-,455
DO	,300	-,916(*)	,881(*)	,186	,300	,300
BOD	,567	,567	-,662	,350	,567	,567
NO_3N	,166	-,649	,484	,195	,166	,166
NO_2N	-,293	-,293	,570	-,347	-,293	-,293
NH_4N	-,115	,996(**)	-,948(**)	,214	-,115	-,115
Cu	,972(**)	-,268	,117	,733	,972(**)	,972(**)
Ni	,728	,029	-,161	,380	,728	,728
Fe	,919(**)	-,033	-,139	,530	,919(**)	,919(**)
Mn	,259	-,440	,378	,460	,919(**)	,259
B	,111	,745	-,729	-,040	,111	,111
Al	-,137	-,191	,446	,003	-,137	-,137
Cl	,833(*)	-,223	,133	,905(*)	,833(*)	,833(*)
Tcol	,733	-,229	,078	,852(*)	,733	,733
F. col	,868(*)	-,252	,076	,832(*)	,868(*)	,868(*)
pH	,210	-,786	,866(*)	-,259	,000	,126

**: $p<0.01$
*: $p<0.05$



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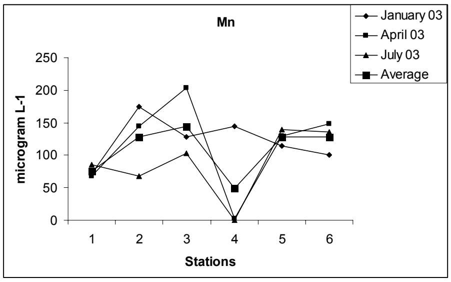

	Water Quality Clasis			
	I	II	III	IV
Ni ($\mu g\ l^{-1}$)	20	50	200	> 200
Cu ($\mu g\ l^{-1}$)	20	50	200	> 200
Cr^{+6} ($\mu g\ l^{-1}$)	trace	20	50	> 50
Fe ($\mu g\ l^{-1}$)	300	1000	5000	> 5000
Mn ($\mu g\ l^{-1}$)	100	500	3000	> 3000

e f

Figure 5. Some heavy metal concentration of the water of MDL in the period of investigation. a- Ni concentration of the water of six sampling sites; b- Cu concentration; c- Cr concentration; d-Fe concentration; e-Mn concentration; f- the classes of the water quality of six sampling sites of MDL according to the criteria of inland water quality that is commonly used in Turkey (Anonymous, 1988).

DISCUSSION

We found that the littoral zone of Dam Lake was dominated by two group invertebrates, Oligochaeta and Chironomidae, is typical of many freshwater systems. As we mentioned above total of 56 invertebrate taxa were recorded from the MDL. The greatest abundance and diversity were recorded at stations 2, 1, and 3. Canonical correspondence analysis results showed that vegetation was the most important factor for distribution of the oligochete species. In similiar way, all the selected chironomid taxa density increased with vegetation, third level of DO and second level of temperature. The lowest value, at station 4, may be the result of the water pH, which is higher than in the other stations, lack of aquatic vegetation and of the small amount of organic particles available to invertebrates. Moreover, the lowest evenness was recorded at station IV; it is caused by both the lowest taxa diversity and the high percentages of three Oligochaeta taxa: *Psammoryctides albicola* (10,7 %), *Limnodrilus hoffmeisteri* (10 %) and *Cladotanytarsus mancus* (10,7 %). As can be seen from Fig. 2, stations 1 and 2 were (outlet and inlet stations respectively) the hydromorphological structures (such as substrate, vegetation), and environmental parameters were very similar each other while these features were different from dam lake stations. Moreover, it is clear that dam lake invertebrate fauna and inlet-outlet fauna are different each other (Table 2). This may be result of the conversion of a fluviatile ecosystem. It’s known that the river continuum is profoundly interrupted when dams are employed by man to impound or divert river flow. Impoundment of rivers involves the building of barriers (dam) to keep backwater and raise its level, leading to the formation of reservoirs (man-made lakes). The conversion of a fluviatile ecosystem to a lacustrine one by the impoundment of rivers brings about structural, physical and chemical changes, which affect the biota [18, 19]. Also, similar studies should be repeated periodically in MDL to determine the future of the river and dam lake fauna. In addition, the concentrations of Cu, Cr, Ni in the MDL’ water surpass the upper limits. Winberg [20] has proposed a pollution index, which assumes that clean waters are dominated by larvae of the subfamily Orthocladiinae and polluted water by larvae of the subfamily Tanypodinae. Winner et al. [21] did not validate this index in relation. They found dominance of Orthocladiinae in polluted with heavy metals. The high number of individual of some Orthocladiin species namely *Nanocladius bicolor* found at the most polluted site (station 2) in respect of heavy metal of the present study is generally in agreement with Winner et al. [21] and other studies [1, 22]. As can be seen in Table 3, other chironomid species, *Endochironomus tentans, Polypedilum scalaenum, Chironomus* (*Camptochironomus*) *tentans* and *Cricotopus* (*Cricotopus*) *tremulus*, showed that significant positive correlation with the metal concentration of water.

Consequently, irrigation, sewage system, variable flow rate, temperature etc. affect the quality of water in MDL. The structure of benthic invertebrate fauna in the MDL changes with effects of environmental variables. The important changes in the water quality parameters are obvious reflection of alterations in the stream continuum due to Dam Lake and these have direct influence on the structure of stream benthic invertebrates' community. Ogbeibu and Oribhabor [19] were reported that the impoundment creates a lacustrine system in a stream continuum and generally brings about changes in water quality and the longitudinal distribution of species. Our results were supported their results.

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