THE EFFECT OF ORGANIC POLLUTION ON BENTHIC MACROINVERTEBRATE FAUNA IN THE KIRMIR CREEK IN THE SAKARYA BASIN

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ABSTRACT

Kirmir Creek is an arm of Sakarya River which is one of the important rivers in the Middle Anatolia Region in Turkey. Pollution takes effects almost every waterbody on the Earth. Only differs pollution percentage of water sources. Organically originated wastes such as domesticated discharges and wastes from food industries release to the Kirmir Creek without treatment.

In this study, the qualitative and quantitative properties and seasonal distribution of the macroinvertebrates of Kirmir Creek were investigated. For this purpose, 3 different stations were selected to take sediment and water samples monthly in one year. Sediment was exampled by Ekman sampler The benthic fauna of the Kirmir Creek was detected consisting of 13 animal groups. They were observed as biomass. Percentages of the groups were indicated as 58,32±21.69% Tubificidae, 17.69±13.82% Physidae, 14.35±20.85% Chironomidae, and 9,64% others in the station 1; 56.37±33.00% Tubificidae, 15.79±27.88% Libellulidae, 9.29±18.44% Physidae, and 18,55% others in the station 2; 98.23±4.07% Unionidae, 1,77±0,35% Libellulidae and others98.23±4.07 in the station 3. These animals tolerant to pollution showed that the Kirmir Creek was under the impact of organic pollution.

Key Words: Macroinvertebrate, benthic fauna, Kirmir Creek, organic pollution.

Sakarya Havzası Kirmir Çayı 'nın Bentik Makroomurgasız Faunası Üzerine Organik Kirliğin Etkisi

ÖZET

Kirmir Çayı Türkiye'nin Orta Anadolu Bölgesinin en önemli nehirlerinden biri olan Sakarya Nehri'nin bir koludur. Kirlilik dünya üzerindeki hemen hemen her su kaynağını etkisi altına almıştır. Yalnızca Su kaynaklarının kirlenme yüzdesi farklılıdır. Evsel ve gıda endüstrüsü atıkları gibi organik kökenli atıklar arıtma yapılmaksızın Kirmir Çayı'na bırakılmaktadır.

Bu çalışmada, Kirmir çayının makroomurgasızlarının kalitatif ve kantitatif özellikleri ve mevsimsel dağılımları incelenmiştir. Bu amaçla, bir yıl süreyle aylık su ve sediment örnekleri almak için üç farklı istasyon seçilmiştir. Kirmir Çayı'nın bentik faunasının 13 hayvan grubundan oluştuğu saptanmıştır. Bunların biyomas miktarları tesbit edilmiştir. Grupların yüzdeleri, istasyon 1'de %58,32±21.69% Tubificidae, % 17.69±13.82 Physidae, % 14.35±20.85 Chironomidae ve % 9,64 diğer; istasyon 2'de % 56.37±33.00 Tubificidae, % 15.79±27.88 Libellulidae, % 9.29±18.44 Physidae, % 18,55 diğer; istasyon 3'de % 98.23±4.07 Unionidae, % 1,77 diğer olarak belirtilmiştir. Kirliliğe dayanıklı bu hayvanlar Kirmir Çayı'nın organik kirlilik etkisi altında olduğunu göstermiştir.

Anahtar Sözcükler: Makroinvertebrata, bentik fauna, Kirmir Çayı, organik kirlilik.

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INTRODUCTION

Presently, water bodies have been under the effects of intensive pollutions all over the world. It can be ordered the causes of water pollution such as soil erosion, decomposition of plants, wastes originated from animals, chemicals for agricultural control in agricultural activities, industrial, chemical, atmospheric, physiological, biological, pollutants, sewage, wastes caused by secretly burring noxious containers, matters coming from transportation, medical contaminants carried epidemic diseases, matters carried by winds and rigid rubbish are directly given creeks, lakes, puddles, rivers, and seas.

Water pollutants originate from urban, industrial, agricultural, and natural areas. All contaminants coming from different sources mix together and affect whole body of water. Pollutants can be characterized in five types, organic, inorganic, microbiotic, radioactive & hazardous wastes, and hot water wastes from energy rectors.

Water is the most important element for living things comprised 60-90% of water. Total mass of water on the world is 1386 millions km^3. 3% of Earth water contains the freshwater (41,580,000 km^3), which can be usable by humans. 97% of it representes oceans, seas & bays (1,344,420,000 km^3). Freshwater constitutes 30.1% of ground water (12,515,580 km^3), 68.7% of ice & glaciers (28,565,460 km^3), 0.3% of surface water (km^3) and 0.9% of other (374,220 km^3). Surface water contains 87% of lakes (108,523 km^3), 11% of swaps (13,720 km^3) and 2% of rivers (2494 km^3).

Various methods measuring wastewater quality are present. Virtual laboratory tests such as BOD, biochemical oxygen demand and COD, chemical oxygen demand are used for water analysis to classify it. Another is a biological test, which is used bioindicators demostrating whether or not water is polluted by any comtaminants. Abundance or biomass and distribution of macroinvertebrates are investigated. Therefore, polluted areas are invasted by tolerant animals and uninfected regions are preferred by pollution-sensitive species. Because aquatic invertebrates shows different tollerance to different kinds of pollutants.

Woodall et al. (1972) investigated number and biomass of benthic fauna in four different watersheds of Appalachian Stream that showed separate results from each other. Because they took different allochthonous detritus inputs. Cosser (1988) examined benthic fauna and water quality characteristics of Gowrie Creek, impacted by organic pollution. Most of the community was Tubificidae, Chironomidae, Gastropoda. Dumnicka et al. (1988) studied effects of pollution on benthic community in the Vistula River. Olive et al. (1988) used macroinvertebrates to indicate water quality of the Cuyahoga River. Rae (1989) determined fourteen *Chironomid* genera to classify water quality. Seager and Abrahams (1990) indicated that sewer overflows could be a significant impact on the structure and diversity of benthic fauna in the Pendle River. Willemsen et al. (1990) considered the effects of urban storm sewage discharges to sessile diatoms and benthic fauna in the River of Netherlands. Whitehurst (1991) explored macroinvertebrate populations of four water bodies (River Adur, Chess Stream, River Ouse, Eridge Stream). He calculated *Gammarus:Asellus* ratio, BMWP (Biological Monitoring Working Party), ASPT (Average Scores per Taxon), Chandler scores and Extended Trent Biotic Index and uncovered that *Gammarus:Asellus* ratio is related with poor water quality. Lang and Reymond (1993) discovered a positive relationship between macroinvertebrate diversity and sampling site altitute. Because human population and organic pollution decreased while altitute rised. Zamora-Munoz et al. (1993) found that organic pollution affected distribution and number of Ephemeroptera and Plecoptera in the Rio Monarchil. Walsh et al. (2001) studied the effects of urbanization on benthic macroinvertebrate groups in streams of Melbourne area. Fenoglio, et al. (2002) used several biotic index to monitor benthic macroinvertebrate composition in the Nicaragua River. He found IBE (Indice Biotico Esteso) index, easier, less time-consuming and cheaper. Camargo (2004) researched correlation between benthic fauna and aquatic environmental conditions in the Iberian Peninsula. He calculated total BMWP, average BMWP and ASPT values. Semenchenko and Moroz (2005) compared six indices (TBI, FBI, BMWP, ASPT, BBI, and EPT) in the Berezina River. TBI, BMWP, and EPT indices were the highest sensitive and enough to show water quality changes.

Geldiay and Bilgin (1969) determined Mollusca species at some regions of Turkey. Şahin et al. (1988) identified Chironomidae larvae in Gökçeada. Şahin (1991) examined Chironomidae individuals in the Eastren Anatolia. Although earlier studies on rivers were done about macroinvertebrate community structure in Turkey, studies are currently focus on effects of diverse pollutions to macroinvertebrate. Kazanci and Girgin (1998) used physico-chemical parameters and Oligochaeta species as bioindicators to evaluate water quality of the Ankara Stream.

In this study, the impact of organic pollution to the Kirmir Creek was investigated by observating diversity changes of benthic community.

MATERIALS and METHODS

This study was carried out in the Kirmir Creek in the Sakarya River basin. Three stations, situated between Yeşilöz and Kızılcahamam province (60 km long) were assigned on the Kirmir Creek (130 km long) for taking benthic samples and measuring water parameters (Figure 1). The Kirmir Creek locates in the North-West part of the Middle Anatolian Region and is on the 40-41° N and 32-33° E of the basin in the boundaries of Ankara. The depth was generally shallow (30-50 cm), but it reached 2-3 m deep in some points. The bottom structure was sometimes sandy, stony and muddy.

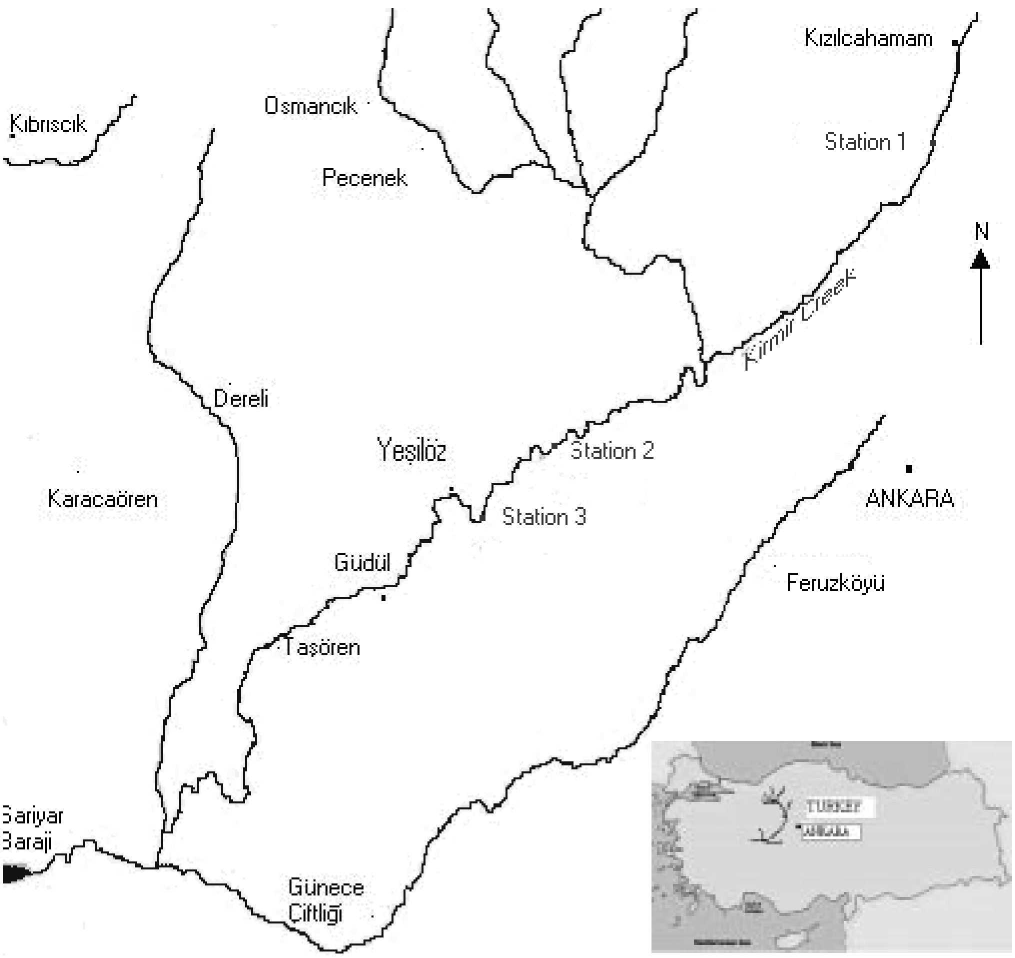

Figure 1. Map of study area in the Kirmir Creek (1:1.000.000 ölçekli) http://www.multimap.com/map/.

During a year, samples were monthly collected twice a site by Ekman sampler (15x15 cm). Every sample was placed in a plastic bag, which was marked for site, sample number and date. Samples transported to labratory and stored refrigerator until they were sieved (mesh-size 210-3360 µm). Collected macroinvertebrates were conserved into small bottles containing 5% formaldehite to identify them taxonomically as family level under invert and dark field microscopes. For identification, various sources were used (Edmondson, 1959; Macan, 1975). After each taxa was weighted 0.01 g, their biomass were calculated as g/m^2.

Water physical parameters were measured at three sites. At station 1, temperature was 7-26 °C, DO (çözünmüş oksijen) 5.9-11.6 mg/L, pH 5.2-12.5. At station 2, temperature was 4-28 °C, DO 8.4-14.9 mg/L, pH 7.2-10.5. At station 3, temperature ranged 6-25 °C, DO 7.3-10.6 mg/L, pH 6.5-9.2 during the year.

Means and standard deviations of biomass were calculated for each site and each month. In order to determine biomass differences between sampling sites and months, one way of analysis of variance (ANOVA) and Duncan tests were done (SSPS).

Biological Monitoring Working Party (BMWP) protocol was used. BMWP scores was totally identified number for each family of found organisms in the Kirmir. Then this score was divided to number of taxa (each species of organism is a taxon) or family to give the Average Score Per Taxon (ASPT) (Anonymous, 2008).

RESULTS

In this study, thirteen taxa were distinguished. There were 2 families (Chironomidae, Tabanidae) in diptera, 1 family (Heptagenidae) in Ephemeroptera, 1 family (Dytiscidae) in Coleoptera, 1 family (Hydropsychidae) in Tricoptera, 1 family (Libellulidae) in Odonata, 1 family (Tubificidae) in Oligochaeta, 3 families (Lymnaeidae, Physidae, Planorbidae) in Gastropoda, 2 families (Unionidae, Sphaeridae) in Bivalvia, and 1 animal in Hirudinea subclassis.

Tubificidae had the highest abundance and biomass at the first stations. The most seen invertebrates in the Kirmir Creek were Tubificidae, Chironomidae, Physidae, Unionidae (Table 1).

Table 1. Annual abundance (ind/m^2) and biomass (g/m^2) of benthic fauna in the Kirmir Creek

Stations	1		2		3	
	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass
Chironomid	33,798±5,274.	172.20±21.27	3,419±332.9	6.46±0.55	2,776±205.1	7.37±0.77
Tubificidae	230,774±13,83	741.51±37.18	46,862±2546.1	104.21±4.92	40,526±2444.6	129.40±7.34
Physidae	11,731±1475.7	265.76±20.85	5,797±1147.6	26.58±4.66	378±73.7	4.26±0.92
Sphaeridae	11,440±859.5	117.74±6,35	155±44.7	4.17±1.20	0	0.00
Tabanidae	333±69.0	1.85±0.42	576±104.4	3.22±0.45	89±25.7	0.28±0.08
Heptagenid	44±12.7	0.06±0.02	44±12.7	0.21±0.06	422±121.8	0.00
Planorbidae	133±38.4	5.93±1.71	355±69.8	1.45±0.28	1,043±174.6	0.00
Hirudinea	508±52.1	12.32±2.06	44±19.1	0.51±0.15	0	0.00
Dytiscinae	0	0.00	444±77.2	0.50±0.09	0	0.00
Hydropsych	0	0.00	44±12.7	0.40±0.12	0	0.00
Libellulidae	0	0.00	265±34.0	49.47±8.81	244±47.7	25.47±4.97
Lymnaeida	0	0.00	44±12.7	1.94±0.45	288±57.8	4.22±0.79
Unionidae	0	0.00	44±12.7	250.06±72.19	1,884±94.9	35,507.62±203
Total	288,761±63,41	1,317.37±53.1	58,093±12,852.	449.18±69.52	47,650±11,107.	35,678.63±203

Annual abundance and biomass of Tubificidae revealed that upsteram (station 1) was more polluted than downstream (station 2, 3). There was a difference between abundance and biomass value among stations. The highest abundance (Tubificidae) was seen at station 1, although The highest biomass (Unionidae) occurred at station 3. Depending on sampling sites and months differences were found significant ($p<0.05$).

At station 1, benthic fauna composition was 5 taxa (Figure 2). Most of the biomass was comprised with Tubificidae average 58,32±21.69%. They became maximum (98.33%) in May. During eight months Tubifex was in company with its cocoons (was included to the weight), but they showed up in March and did not seen in the hottest months of the year in August, September and October. Physidae was the second highest family (17.69±13.82%)especially in February, March, July, December, and January The average biomass of the third dominant taxon Chironomidae was 14.35±20.85% and maximally ranged 30.15-49.43% from June to October. Others was 9,64%.

At station 2, diversity was the highest and there were totally thirtheen animals (Figure 3). Tubificidae was the dominant family 56.37±33.00% (34.37-99.82%) and had less than 10% in June and October. Libellulidae took place 15.79±27.88% as the second highest group and was 22.67-84.49% in May, October, November, and December). Physidae seemed (9.29±18.44%) 23.41-59.00% in April, August, and December. Others (18,55%) were Chironomidae, Tabanidae, Hydropsychidae, Dytiscidae, Hydropsychidae, Lymnaeidae, Planorbidae, Sphaeridae, Unionidae, Hirudinae.

At station 3, two organisms were seen dominant. Annual biomass of Unionidae was 98.23±4.07% and Libellulidae and others were and 1,77±0,358% (Figure 4).

The reason that each type of species has a different tolerance to each pollutant. The number and type of species in the stream are used as indicators to demonstrate the impact of organic and chemical pollution to water quality. Based indicator species some indeses (BMWP, ASPT, or others) are accounted and used rating system at Table 2. BMWP scores and ASPT of Kirmir creek were calculated.

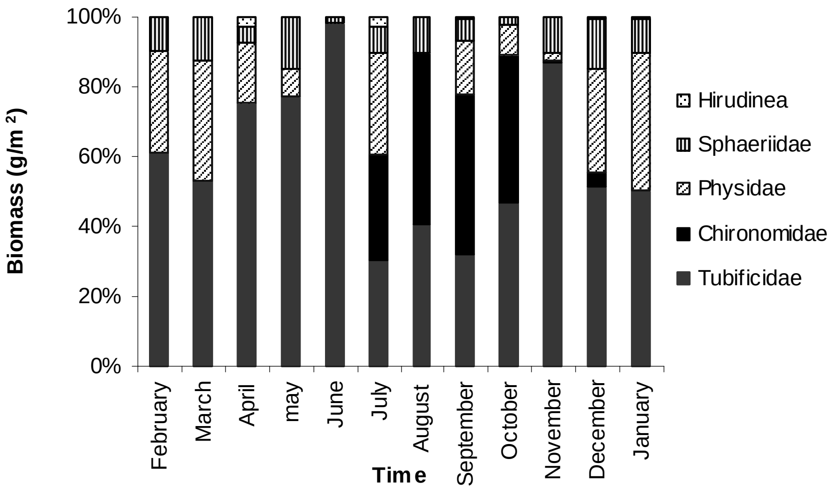

Figure 2. Biomass percentage of macroinvertebrates in station 1

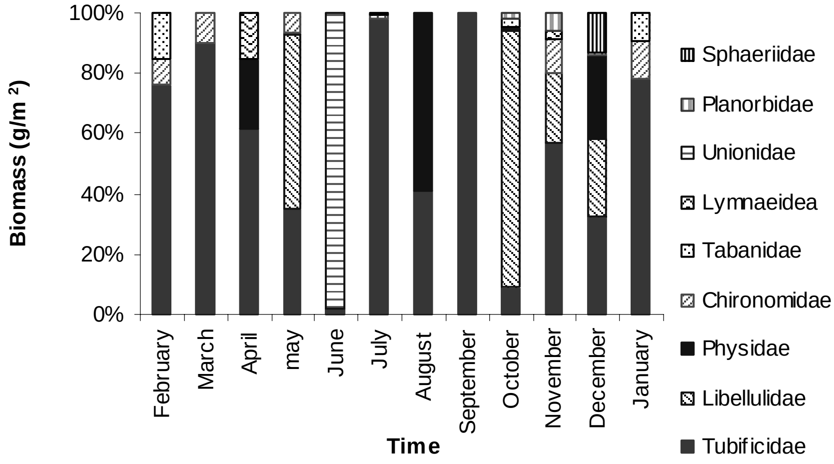

Figure 3. Biomass percentage of macroinvertebrates in station 2

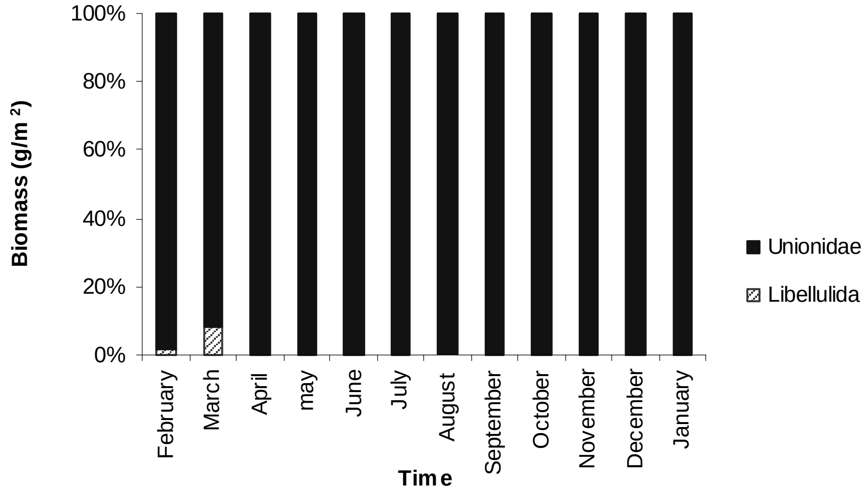

Figure 4. Biomass percentage of macroinvertebrates in station 3

Table 2. BMWP score, water quality category and interpretation

BMWP Score	ASPT	Quality	Interpretation
>150	>5.4	Very good	Unpolluted, unimpacted
101-150	4.81-5.4	Good	Clean, but slightly impacted
51-100	4.21-4.8	Fair	Moderately impacted
16-50	3.61-4.2	Poor	Polluted or impacted
0-15	3.6 or less	Very poor	Heavily polluted

BMWP scores were 29, 56, and 27 for station 1, 2, and 3, respectively (Table 3). According to rating system of water quality, three stations of Kirmir were showed impacted quality. ASPT was 3 – 4 (Table 3). Those scores were interpreted that station 2 had moderate water quality, but the station 1 and 3 were impacted.

Table 3. Total abundance, total biomass, number of taxon, BMWP and ASPT

Station	1	2	3
Total Abundance (ind/m^2)	288,761±63,412.5	58,093±12,852.7	47,650±11,107.5
Total Biomass (g/m^2)	1,317.37±53.10	449.18±69.52	35,678.63±2,036.66
Number of taxon	8	13	7
BMWP	29	56	27
ASPT	3.6	4.3	3.9

DISCUSSION

The most abundant families in the Kirmir Creek are Tubificidae, Chironomidae, Physidae, Sphaeridae and Unionidae.

Tubificidae was the most common family. This result indicated that the creek was polluted with organic substances. Tubificidae is accepted as bioindicator animals that live in polluted water (Woodiwiss, 1964; Chandler, 1970; Hart et al., 1974 (cited in Kazanci and Girgin, 1998)). Seager and Abrahams (1990) also foud that Oligochaetes appeared dominant under the chronic effect of storm sewage discharges. They indicated that diversity of macroinvertebrates decreased and animal community changed and number of Tubificidae (Oligochaeta) rised. This study notified the identical results as well.

Macroinvertebrate community structure of the Kirmir Creek was identified by Kucuk (2006). It was evaluated that the annual abundances were 288,761 ind/m^2, 58,093 ind/m^2, 47,650 ind/m^2, for station 1, 2, 3, respectively. This study investigated the same creek in term of biomass. But results showed that the third station had the most polluted area and the highest organic load. Thirteen families were gradually distributed in the three regions due to food availability. Water quality of three stations evaluated in saprobic system. The station 1 was polysaprobic, station 2 and 3 were alfa-mesosaprobic in the Table 4. Kazanci and Girgin (1998) also signified the Ankara Stream over impact of organic pollution between alfa-mesosaprobic and polysaprobic zones.

Table 4. Ecological characterics of stations

Site	Water Quality Zones	Substratum Structure	Flow Rate	Dominant Animals
1	Polysaprobic	marshy, detrius	Slow	Tubificidae, Physidae, Chironomidae
2	Alfa-mesosaprobic	gravelly, sandy, vegetation	Rapid	Tubificidae, Libellulidae, Physidae, Chironomidae
3	Alfa-mesosaprobic	muddy, vegetation	Medium	Unionidae, Libellulidae

When effluents discharged to waters, community structure and density change. Cosser (1988) revealed how organic pollution modifies water ecosystem. Food chain alters from heterotrophic to autotrophic. Algae and macrophytes grow prolifically owing to oxygen deplation, present of nitrate and phosphate. Some types of Chironomidae (especially *Chironomus spp.*), Tubificidae (*Tubifex tubifex* and *Limnodrilus hoffmeisteri*), gastropod (*Planorbis balonnensis* and *Physa spp.*) developed large populations due to high tolerance to organic pollution. In this study, some of those taxa are found highly, but autotrophic system was not dominant. It may be direct discharge of sewage to the Kirmir Creek. There was no treatment plants in province of Ankara. Especially, sewage treatment plants are only instructed in big cities. Everywhere on the world people face more problems to get enough amount of clean water. Waters are under risk of pollution and global warming. It is hard to protect waters when the world becomes more crowded.

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