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RESEARCH ARTICLE

Biomonitoring of an urban stream (Ova Stream, Ankara, Turkey) using the Belgian Biotic Index

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ABSTRACT

1. The purpose of this study is to compare the water quality of the Ova Stream, an urban stream and its tributaries in May 1991, 1992 with that of 2008, by using benthic macroinvertebrates and some chemical variables.
2. Benthic macroinvertebrate and water samples were taken from four sites along the stream (from upstream to downstream).
3. Belgian Biotic Index was used to assess the water quality.
4. It is observed that the pollution intolerant groups were replaced by tolerant groups over a period of 16 years. Ephemeropterans were disappeared or reduced in number as the result of increasing pollution. *Eristalis tenax,* which is an indicator of polluted waters, was recorded for the first time in this stream in the site 18 in 2008.

KEY WORDS: Belgian Biotic Index, benthic macroinvertebrates, biomonitoring, urban stream, water quality.

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Kentsel bir akarsuyun (Ova Çayı Ankara, Türkiye) Belçika Biyotik İndeks'i kullanılarak izlenmesi

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ÖZ

1. Bu çalışmanın amacı kentsel bir akarsu olan Ova Çayı ve kollarının Mayıs 1991, 1992 ve 2008 deki su kalitesini, bentik makroinvertebratlar ve bazı kimyasal parametreler kullanarak karşılaştırmaktır.
2. Akarsu boyunca dört istasyondan su örnekleri ve bentik makroinvertebrat örnekleri alınmıştır (akarsuyun yukarı kesimlerinden aşağı kesimlerine doğru).
3. Su kalitesini belirlemek için Belçika Biyotik İndeksi kullanılmıştır.
4. Onaltı yıllık süreçte, kirliliğe dirençsiz grupların kirliliğe dirençli gruplarla yer değiştirdiği görülmüştür. Kirliliğin artmasıyla ephemeropterler sayıca azalmış ya da ortadan kalkmıştır. Kirli suların göstergesi olan *Eristalis tenax* ilk kez 2008 yılında 18. örnekleme noktasından kaydedilmiştir.

ANAHTAR KELİMELER: Belçika Biyotik İndeksi, bentik makroinvertebratlar, biyolojik izleme, kentsel akarsu, su kalitesi.

INTRODUCTION

Urban rivers and streams are usually affected by hydromorphological alterations (e.g. dams or reinforced banks) and water quality deterioration (Wood and Armitage 1997, Wood and Armitage 1999). Urban rivers are more prone to pollution mainly due to their close proximity to many pollution sources like wastewater discharge points, on-site sanitation systems for domestic and institutional sources, industrial effluent discharge points, and solid-waste disposal sites (Mbuligwe and Kaseva 2005). The effect of urbanization on aquatic environments and aquatic organisms have been investigated by many authors (e.g. Lenat and Crawford 1994, Wear *et al.* 1998, Paul and Meyer 2001, Roy *et el.* 2003, Girgin *et al.* 2003, Booth *et al.* 2004, Miller and Boulton 2005, Ortiz *et al.* 2005, Azrina *et al.* 2006, Tavzes *et al.* 2006¸ Ortiz and Puig 2007, Vermonden *et al.* 2009).

Many methods have been used to assess the water quality. Because of the limitations of chemical monitoring, biological monitoring is preferred for long-term observation. Macro benthic invertebrates are widely used as bioindicators in the American and European ecoregions, while in Turkey the water quality assessment by biotic indices, using benthic macro invertebrates, has started in recent years. In Turkey, the first use of biotic indices for streams was performed by DSI (State Water and Hydraulic Works) together with British experts in 1992. For this purpose, a project was carried out in the Seyhan and Sakarya basins. In this study, the BMWP (Biomonitoring Working Party) score system and TBI (Trent Biotic Index) were used (DSI 1992). Then, in a project carried out at the Köyceğiz-Dalyan Nature Reserve Area, the application of the Belgian Biotic Index was performed for the first time in Turkey (Kazancı 1993, Kazancı and Dügel 2000). A new index was also created for the streams in that region, based on the Turkish fauna (Kazancı 1993). These kind of studies are continuously growing in Turkey, referring to the publications of Girgin and Kazancı 1997, Girgin *et al.* 1997, Kazancı, *et al.* 1997, Duran *et al.* 2003, Dügel and Kazancı 2004, Duran 2006, Öz and Kazancı 2008, Kalyoncu *et al.* 2008, Kazancı *et al.* 2008, Girgin 2010, Kazanci and Türkmen 2010).

The purpose of this study is to compare the water quality of the Ova Stream, an urban stream and its tributaries in 1991, 1992 with that of 2008, by using benthic macroinvertebrates and some chemical variables. In 1991, 1992, and 2008 the same stations were selected along the stream. The Belgian Biotic Index (BBI) was applied to assess the biological water quality of the Ova Stream. In addition, the other purpose of this study is to observe the change in the distribution of benthic macroinvertebrates in respect with water quality changes.

In 1991 and 1992 the waters were discharged in the study area without any preliminary treatment. Recently, a water treatment plant (WTP) was built in the close vicinity of Tatlar village in the Zir Valley and it has started operating in 2007. The WTP is situated close to the Ankara Stream, downstream from the point where it mixes with the Zir Stream. This study also aims to observe the effect of WTP to the water quality of the stream.

MATERIALS AND METHODS

Site Description

The study area is located in the Sakarya River basin of Central Anatolia in Turkey. The main tributary of the Sakarya River is called the Ankara Stream. The Ova Stream is an important tributary of the northern part of the Ankara Stream, and it is located in the Murted Plateau. It is a perennial stream used for irrigation, sand and gravel extraction. The Ova stream, in the town of Kazan, is exposed to the discharge of massive sewage waste and agricultural pollutants. The Ova stream is the major stream of the Murted Plateau. The Pazar and Mera Streams flowing into the Kurtboğazı Dam are important tributaries of the Ova Stream. Both streams are the upstream parts of the Ova Stream. The Zir Stream, in the Zir Valley, is in the downstream section of the Ova Stream. The Zir Valley (about 8 km in length) is located approximately 30 km west of Ankara. The long and deep Zir valley and Zir Stream are situated in the Murted Plateau. They are affected by human activities. There are medical waste disposal sites and sand quarries near the Zir Valley (Kazancı *et al.* 1997, Şahin and Bekişoğlu 2009).

The upstream area is in Kızılcahamam, while the downstream area is in Sincan. Four sampling stations were established along the stream. Chemical and biological variables assessed in the years 1991 and 1992 have been obtained from Girgin and Kazancı (1994).

(Site 14) The Mera Stream (40° 20’ 00.65” N; 32° 42’ 03.56” E) —It is an inlet of the Kurtboğazı Dam. The stream bank was composed of reed and alluvium. The stream bed is large and consists of pebbles and stones. It is surrounded by some villages and fields. This site (14) is in the upstream.

(Site 15) The Pazar Stream (40° 19’ 39.53” N; 32° 43’ 20.80” E) —It is an inlet of the Kurtboğazı Dam. It is a little stream. The stream bank has an alluvial and gravelly structure. The stream bed consists of pebbles and stones. It is surrounded by some villages, fields and poultry yards. This site (15) is in the upstream.

(Site 17) The Ankara Stream (main branch) (39° 53’ 13.53” N; 32° 27’ 45.46” E) — This station is on the Ankara Stream, downstream from the point where it mixes with the

Zir Stream. The stream bank has a marshy structure and is surrounded by vegetation. The stream bed is composed of marsh land. This site is in the downstream.

(Site 18) The Zir Stream (39° 58' 54.15" N; 32° 31' 00.72" E) —It is the downstream of the Ova Stream and it is close to the connection point with the Ankara Stream. The stream bank and stream bed are composed mainly of clay and silt. The wastes of some slaughterhouses and packaging industry facilities in the Sincan district mix into the stream.

The WTP has been established in the close vicinity of Tatlar village in the Zir Valley and it has started operating in 2007. While site 17 was located after water treatment plant (AWTP), the other sites (14, 15, and 18) were located before water treatment plant (BWTP).

The Ova Stream (main tributary) in the town of Kazan receives all the sewage waste of the town. For that reason, benthic macro invertebrates and the water were not sampled in this area.

Sampling

Water samples were taken from the four stations mentioned above. In each station, dissolved oxygen and water temperature was measured with portable instruments (HACH oxygen meter) in the field. In 1991 and 1992, ammonia and pH were measured in the laboratory according to the Standard methods of DSI (State Water and Hydraulic Works) (DSI, 1981). In 2008 a HACH DR 2000 photometer and a HACH oxygenmeter were used for spectrophotometric measurements.

The benthic macroinvertebrates were sampled using a D-framed kick net. Samples were collected from a section on the stream bed, measuring 20 m for a period of fifteen minutes. Sites with strong water currents were specifically selected for sampling. However, the sampling was done in different microhabitats that reflect all the features of the stations. Samples were conserved in 80 % ethyl alcohol and were sorted from the sediment in the laboratory. An Olympus CX21 binocular microscope and Phywe stereo microscope were used for taxonomic identification.

Biotic and Diversity Indices

The Belgian Biotic Index was used to assess the water quality in the present study. In the Belgian Biotic Index, in comparison with most other assessment methods, the organisms are only identified on a family or genus level and not on a species level (Metcalfe 1989, De Pauw *et al.* 1999). For this reason, the taxonomic identification was done at genus or family levels. Shannon index was used to assess the biological diversity (Southwood 1991).

RESULTS AND DISCUSSION

Physico-chemical variables

The values of some chemical variables of the Ova Stream in May 1991, May 1992, and May 2008 are indicated in Table 1. In May 1992, oxygenmeter was out of order, so dissolved oxygen and water temperature could not be measured. In sites 14, 15, and 18 dissolved oxygen values were lower in 2008 than in 1991, while pH values and water temperature were higher in 2008 than in 1991. Despite the WTP, the lowest value of dissolved oxygen was measured as 0.3 mg/l in site 17 in 2008. The highest NH_4-N concentration was measured as 38.2 mg/l in site 17 in 2008 (Table 1). Dissolved oxygen levels drop below acceptable levels to protect aquatic life such as polluted sites (Askew *et al.*, 2003).

Table 1. Measured physico-chemical variables in Ova Stream.

	May 1991				May 1992				May 2008			
Sites	14	15	18	17	14	15	18	17	14	15	18	17 (AWTP)
DO mg/l	9	5.4	6.8	-	-	-	-	-	8.8	5	2.5	0.3
pH	8.2	7.9	7.2	7.1	8.4	8.1	7.8	7.8	8.6	8.1	8.1	7.7
T ºC	16	15	17	-	-	-	-	-	17.5	17.5	17.4	17.5
NH_4-N mg/l	0	3	3.27	4.87	0	0	10.7	10.7	0.01	0	-	38.2

Abbreviations: DO: dissolved oxygen, AWTP: after water treatment plant (water treatment plant commenced operation in 2007)

Distribution of Benthic Macroinvertebrates

Thirty-two taxa were identified in this study (Table 2). Distribution of the major taxa and their dominance (%) values in the Ova Stream are shown in Figure 1. As it can be observed in Figure 1, Sites 14 and 15 were dominated by Ephemeroptera in 1991 and 1992, while in 2008 Crustacea was the most important taxa in site 14 and Diptera in site 15. Crustacean, *Gammarus* was the dominant genus with 78.7% in site 14 and dipteran, *Tipula* was the dominant genus with 72.7% in site 15 in 2008 (Table 2). In site 18, Odonata was the dominant taxon in 1991 and Ephemeroptera was the dominant taxon in 1992, while in 2008 Diptera was the single taxon,and *Chironomus* was the dominant with 65% in the same site (Figure 1, Table 2). In addition, the dipteran *Eristalis tenax* was recorded for the first time in site 18 in 2008 (Table 2). Ephemeroptera was the dominant taxon in 1991 and 1992, but it disappeared or decreased at the same sites in 2008 (Figure 1).

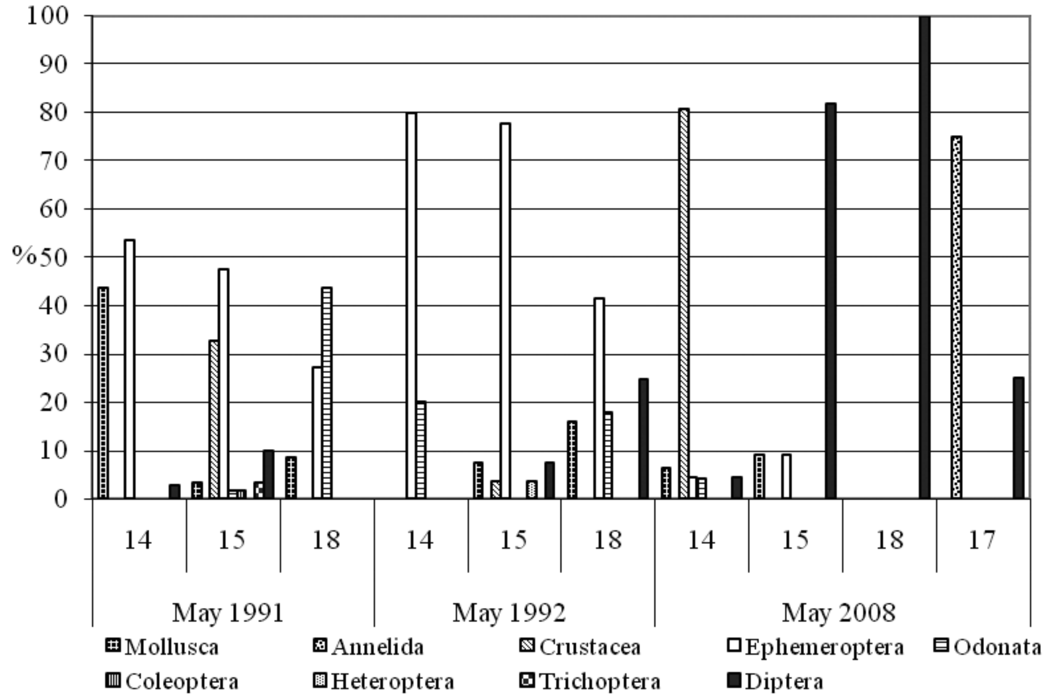

Figure 1. Distribution of the major taxa and their dominance (%) in the Ova Stream.

According to Ortiz and Puig (2007), nutrient enrichment decrease macroinvertebrate richness (Paul and Meyer 2001) by elimination of sensitive taxa, mostly represented by the insect orders Ephemeroptera, Plecoptera and Trichoptera (EPT; Lenat 1983). Simultaneously, taxa considered resistant to pollution and adapted to unstable habitats, such as midges and oligochaetes, are enhanced (Hynes 1978). This response to nutrient enrichment is well established worldwide, in arctic (Milner and Oswood 2000, Benstead *et al.* 2005), tropical (Ometo *et al.* 2000, Thorne *et al.* 2000), desert (Dor *et al.* 1976, Voelz *et al.* 2005), temperate (Roy *et al.* 2003) and Mediterranean streams (Prat *et al.* 1984, Prenda and Gallardo-Mayenco 1996). In our study, Ephemeroptera was the most common taxon among the EPT groups. According to Merritt and Cummins (1978), members of the order Ephemeroptera are considered to be sensitive to environmental stress and their presence signified relatively clean conditions (Azrina *et al.* 2006). These cited findings support the results of the present study. In this study, ephemeropterans were found to be common in moderately polluted sites, but they were eliminated from heavily polluted sites (Table 2). Pollution-tolerant taxa such as crustaceans, molluscs, and some oligochaets tend to dominate in urban streams (Auckland Regional Council Website). In the present study, Ephemeroptera and Odonata were dominant taxa in 1991 and 1992, while Crustacea (in site 14), Diptera (in sites 15 and 18) and Annelida (in site 17) were dominant taxa in 2008. It is assumed that, due to growing urbanization, pollution intolerant groups were replaced by tolerant groups.

Table 2. Distribution of benthic macroinvertebrates in Ova Stream.

Abbreviations: A: Abundance; D%: Dominance %; NS: no samples; BWTP: before water treatment plant; AWTP: After water treatment plant (water treatment plant commenced operation in 2007); H´: Shannon's diversity index; BBI: Belgian biotik index; MP: moderately polluted; HP: heavily polluted; VHP: very heavily polluted.

		May 1991							May 1992							May 2008							
																BWTP						AWTP*	
		14		15		18		17	14		15		18		17	14		15		18		17	
No		A	D%	A	D%	A	D%	NS	A	D%	A	D%	A	D%	NS	A	D%	A	D%	A	D%	A	D%
	Mollusca																						
1	*Physa*	14	19.7			2	2.7						4	4.0		1	2.1						
2	*Galba*	1	1.4			1	1.4				2	3.7											
3	*Radix*	3	4.2	2	3.3											2	4.3	1	9.1				
4	*Gyraulus*	9	12.7			12	16.4				2	3.7	11	10.9									
5	*Succinea*	2	2.8																				
6	*Pisidium*	2	2.8			2	2.7						1	1.0									
	Annelida																						
7	*Lumbriculus*																					3	75
	Crustacea																						
8	*Asellus*															1	2.1						
9	*Gammarus*			20	32.8						2	3.7				37	78.7						
	Ephemeroptera																						
10	*Baetis*	26	36.6	2	3.3	16	21.9		2	13.3			36	35.6									
11	*Caenis*	12	16.9	27	44.3	4	5.5		10	66.7	42	77.8	6	5.9		2	4.3						
12	*Heptagenia*																	1	9.1				
	Odonata																						
13	*Calopteryx*					5	6.9																
14	*Platycnemis*					26	35.6																

Table 2. (Continued)

15	*Coenagrion*							2	13.3			14	13.9								
16	*Ischnura*					1	1.4					4	4.0								
17	*Onychogomphus*			1	1.6									2	4.3						
18	*Libellula*							1	6.7												
	Coleoptera																				
19	*Dupophilus*			1	1.6																
	Heteroptera																				
20	*Gerris*									2	3.7										
	Trichoptera																				
21	*Hydropsyche*			2	3.3																
	Diptera																				
22	*Tipula*					1	1.4			2	3.7	1	1.0	2	4.3	8	72.7				
23	*Simulium*					1	1.4					14	13.9								
24	*Pentaneurella*	2	2.8							2	3.7										
25	*Orthocladinae*			2	3.3																
26	*Chironomus*					1	1.4					10	9.9					39	65	1	25
27	*Odontomyia*			2	3.3	1	1.4														
28	*Haematopota*															1	9.1				
29	*Tabanus*			1	1.6																
30	*Atherix*			1	1.6													19	31.7		
31	*Muscidae*																	1	1.7		
32	*Eristalis tenax*																	1	1.7		
	Total	71		61		73		15		54		101		47		11		60		4	
	H´	1.74		1.56		1.89		0.99		0.97		1.90		0.89		0.89		0.78		0.56	
	BBI	5		5		5		4		5		5		5		0		0		0	
	Water quality class	III		III		III		IV		III		III		III		V		V		V	
		MP		MP		MP		HP		MP		MP		MP		VHP		VHP		VHP	

The WTP has started operating in 2007. In 2008, benthic macroinvertebrates were sampled in site 17 which is very close to the WTP discharge point. In 2008, taxa richness ranged 4 and 7 at BWTP sites, while it was just 2 at AWTP, in site 17 (Table 2). Only two genera were recorded in this site. *Lumbriculus* (Annelida) was the predominant taxon with 75% and *Chironomus* was the second taxon with 25% (Table 2). *Lumbriculus* was recorded for the first time in the stream system in 2008. As it can be observed in Table 1, in spite of the WTP, the lowest dissolved oxygen concentration (0.3 mg/l) and the highest ammonia concentration (38.2 mg/l) were measured in site 17. Two genera, *Chironomus* and *Lumbriculus* were able to survive in these polluted conditions.

Shannon diversity index was also calculated in the sampling sites. Its value ranges from 1 to 3 in moderate polluted streams, and from 1 to 0 in heavy polluted streams (Mason, 1981). The diversity values found in this study ranged from 0.56 (in site 17 in 2008) to 1.90 (in site 18 in 1992) (Table 2). Values higher than 1.00 were found in sites 14, 15, and 18 in 1991 only. In addition, in site 18 the Shannon Index value was 1.90 in 1992, while the other values were lower than 1.00. Diversity value ranged from 1.56 to 1.89 in 1991 and from 0.97 to 1.90 in 1992. The lowest values were recorded in 2008, ranging from 0.56 to 0.89.

Biomonitoring of Water Quality in 1991, 1992, and 2008

The Belgian Biotic Index (BBI) (De Pauw and Vanhooren, 1983) was used to assess the water quality in the Ova Stream. The biotic index values and the water quality values are indicated in Table 2 and Figure 2. In all three sites in May 1991, BBI values were 5, indicating water quality class III - moderate pollution. In May 1992, sites 15 and 18 had moderate pollution (BBI values were 5 and water quality classes were III), site 14 had heavy pollution (BBI value was 4 and water quality class was IV). In May 2008, BBI values of sites 15, 18, and 17 were 0 (zero), indicating water quality class V - very heavy pollution. In site 14, the BBI value was 5 (water quality class III) in May 2008 and in May 1991, indicating the same status, moderate pollution, for both years. Site 14 is in the upstream. The stream bed is large and the water current is strong. In 2008, DO value was higher in site 14 (8.8 mg/l) than in the other sites (Table 1). In site 18, Mollusca, Ephemeroptera, Odonata and Diptera were recorded in 1991 and 1992, whereas Diptera only was recorded in 2008 (Figure 1). In the present study, *Eristalis tenax* was recorded in site 18 in 2008. This species is an indicator for polisaprobic (heavy polluted) environments (Sporka 2003, Robinson 2005). There were no records of invertebrates in site 17 in 1991 and 1992. In 2008, self-purifying and recovering capacity of the stream could not be observed due to proximity of site 17 to the discharge of WTP.

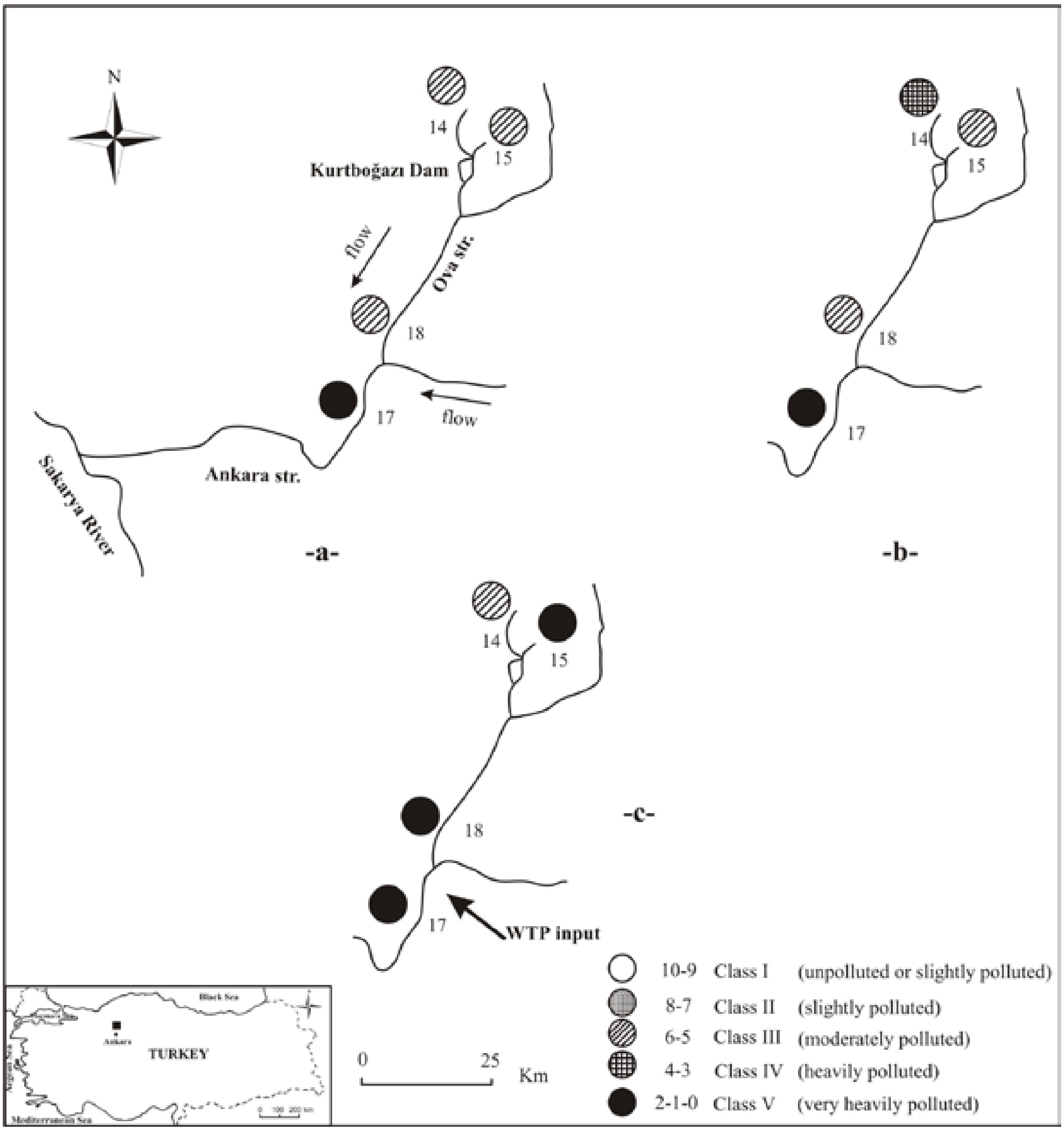

Figure 2. Water quality map of the Ova Stream.
a) May 1991 b) May 1992 c) May 2008

CONCLUSION

Chemical and biological evaluations show that all stations have an increasing pollution over the period of 16 years, due to increasing industrialization and urbanization in the Ova Stream area. Pollution intolerant groups were replaced by tolerant groups. Disappearance or decrease of any group, such as ephemeropterans is the result of increasing pollution. We suggest that the number of WTP systems should be increased within the framework of a future management plan. In this regard, increase of environmental public awareness should also be considered as a priority for the relevant area.

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