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EXPLORATION OF BIOLOGICAL RICHNESS AND WATER QUALITY OF STREAM KELKIT, TOKAT-TURKEY

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SUMMARY

This study examines the biological richness combined with measurement of physicochemical parameters and some biotic indices, in order to determine the water quality at ten different sites along the Niksar part of the stream Kelkit between March 2000 and February 2001. Standard methods have been used to determine the physicochemical properties of water samples. The metal ions were determined by atomic absorption spectrometry after liquid-liquid extraction. Metal accumulation factors were calculated for some macroinvertebrates and fish species. Biological and chemical results are in good agreement with respect to the water quality in the stream Kelkit. In particular, macroinvertebrate and phytoplankton communities responded quite variably probably because of substantial differences in flow regimes. We concluded that a rich biota population in the stream Kelkit will be achievable.

KEYWORDS:
Stream Kelkit, biological richness, water quality, physicochemical analysis, atomic absorption spectrometry.

INTRODUCTION

The biological richness of freshwater in many regions of Anatolia has not been discovered yet. Macrozoobenthos have been rarely used to determine quality of running water in Turkey and biotic indices have not been used by governmental institutions yet. However, in the meanwhile ecological recovery and rehabilitation of aquatic ecosystems have become objectives of many governmental institutions [1]. In order to define the fauna structure in the region biological parameters have to be used. Afterwards, the methods are changed to be appropriate to the members of fauna and a regional index is prepared according to these changes. In our study, the biological richness was defined as accurate as possible and macroinvertebrates and physicochemical parameters were used to determine the water quality.

The main constituent of water are living organisms. The weight percentage of water in invertebrates is about 70% [2]. For instance, typical insects have water contents of 65-75% of fresh weight, although the levels range from only 17% to more than 90% in different life stages of different species [3].

Benthic macroinvertebrates are the group of organisms most widely used for assessment of water resources [4-9]. Water quality determines the number of species, continuity and present densities with the use of biotic indices [10]. However, various researches have been performed for monitoring water quality [11,12].

The stream Kelkit is the longest tributary of the river Yesilırmak which is one of the longest in Turkey (1144,5 km^2, 210 km in length, Q_{max} =978.5 m^3/s, Q_{min}=1.85 m^3/s) with an average discharge of 3224 km^3/s per year. The stream is situated in Northern Turkey, east of the city of Tokat. This part of the stream runs fast in all seasons and receives mainly agricultural runoff, but also urban sewage and little industrial waste.

The major aim of this project was to determine the spatial and temporal pattern in the community structure of biota richness with particular emphasis on the relationships between structure of community and the physical and chemical environment. Furthermore, if macroinvertebrate community structure could be predicted from physicochemical characteristics of the stream, this information might be useful to assess the status of adjacent stream systems.

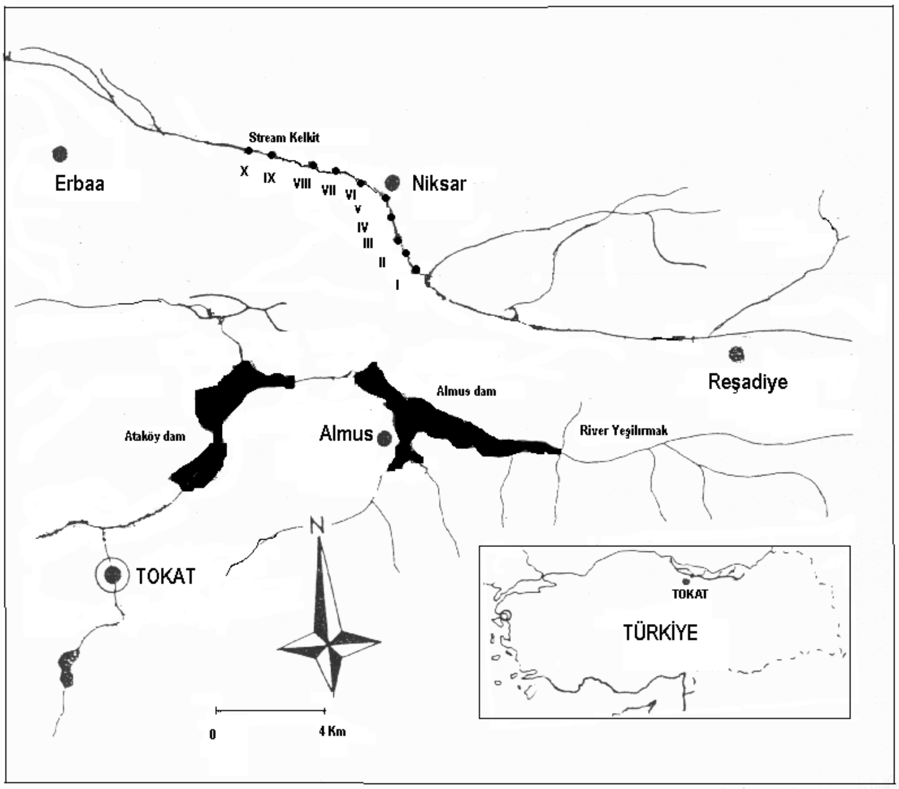

FIGURE 1 - Locations of the stream Kelkit and sampling stations.

MATERIAL AND METHODS

Sampling

Ten sites were sampled for benthic invertebrates monthly from March 2000 to February 2001. Five stations, south of Niksar county, were the first sampling stations and other five, west of Niksar, were the second ones (Fig. 1). The first stations receive mainly agricultural runoff and no industrial wastes (except the waste from one limestone mine). Generally, the bottom of the stream has various sizes of rocks, but gravel is found in the parts nearest to the county centre. The second stations have mostly gravel and in some areas, sand and silt. This part of the stream receives mainly urban sewage, agricultural runoff and little industrial wastewater. Samples were taken six times with a Surber sampler covering an substrate area of 0.1 m^2. The net (mesh size 475µm) was 50 cm long with a straining surface area of 0.77 m^2. Riffle areas were the major habitat of this fast running stream, with a substratum consisting predominantly of gravel and some rocks. When sampling was restricted in some areas, the procedure followed was that outlined by Surber [13]. Larger stones were first picked out and washed into the net to remove pupae and other attached invertebrates. The latter were washed in the field through a sieve and immediately stored in 4% formalin. Invertebrates were then transferred into 70% ethyl alcohol and later identification of macroinvertebrates was carried out to determine the lowest taxa possible (in most cases genus or species). Samples of zooplankton were taken by a plankton net (55 µm) and the phytoplankton using the methods of Sladeckoval [14]. Formalin (4%) was used to preserve them until identification by inverted microscopical analysis.

Temperature, dissolved oxygen, conductivity and pH were measured in the field using portable instruments. The samples were filtered through a 0.45 µm Millipore membrane, immediately acidified to pH ≤ 2 using high purity HNO_3, and kept in the refrigerator at 4 ºC until analysis [15].

Reagents

All reagents were of analytical grade unless otherwise stated. Double-deionised water (Milli-Q Millipore 18.2 $M\Omega cm^{-1}$ resistivity) was used for all dilutions. All the plastics and glassware were cleaned by soaking in dilute HNO_3 (1+9) and rinsed with distilled water prior to use. The stock solutions of metals (1000 mg/l) were obtained by dissolving appropriate salts or the corresponding metals (E. Merck) and further diluted prior to use. APDC was dissolved in a water/ethanol (75/25, v/v) mixture.

FAAS analysis

A Varian SpectrAA-220 flame atomic absorption spectrometer was used in this study. All measurements were carried out in an air/acetylene flame. The operating parameters for working elements were set as recommended by the manufacturer. The wavelengths (nm) used for the determination of the analyses were as follows: Fe: 248.3, Cu: 324.8, Mn: 279.5, Zn: 213.9, Pb: 283.3, Cd: 228.8. Trace metal concentrations were measured by flame atomic absorption spectrometry (FAAS) after preconcentration by liquid-liquid extraction (APDC-MIBK) [16]. Ammonia nitrogen, nitrate, nitrite, sulphate, phosphate, chloride, hardness, organic matter, total dissolved solids and boron in the samples were determined according to APHA, AWWA, and WPCF [17]. The digestion of biological samples were made according to [18] and concentrations of Pb, Cd and Fe, Cu, Mn and Zn were determined using graphite furnace and flame AAS, respectively.

RESULTS AND DISCUSSION

Fourty five species of algae, 4 species of amoebae and 11 of Rotifera were determined up to the genus level (Table 1). The dominant algal groups found were Bacillariophyta: *Achnanthes* (3), *Asterionalla* (1), *Cocconeis* (1), *Cymbella* (4), *Fragillaria* (2), *Synedra* (3), *Tabellari* (1), *Mastogloia* (1), *Navicula* (2), *Pinnularia* (4), *Navicula* (2), *Pinnularia* (4), *Nitzschia* (4) and *Cymatopleura* (3). Additionally, algal flora that is part of Chlorophyta and Cynophyta has been identified. It has been observed that, although the assorted species belonging to Cynophyta are few, the density of these organisms is high. On the other hand, it is found that the number of species belonging to Chlorophyta is high, but their density is low. Stochastic events and circumstances contribute to the variability, but certain species-association may occur preferentially in certain kinds of rivers. For instance, *Navicula* and *Cymbella* are frequently encountered in limestone stream beds. *Zygnema*, *Pinnularia* and *Nitzschia* occurred in less alkaline granites, sand and limestone [19]. Consequently, these observations fit well with the findings in our study. The benthic component is augmented by habitually free-living species common in the stream. According to these results obtained, it was observed that epilith, epipel and epiphyte components mingle each other. This may be partly related to the rates of dislodgement and the flushing out by the flow.

The composition of macroinvertebrate fauna identified as *Platyhelminthes* (1), *Mollusca* (4), *Annelida* (2), *Crustacea* (2) and insecta (31) is shown in Table 2. According to the results, the first stations of the stream Kelkit were dominated by *Plecoptera*, *Ephemeroptera* and *Tricoptera* and found to be "first class" by diversity. The sum results for the first stations were calculated using ecological condition categories and found to be 75 by Chandler Score, 8.1 by BMWP (Biological Monitoring Working Party) Score and 11.2 by Expanded Trent Biotic Index (ETBI). The scores calculated for second stations were 50.9 by Chandler Score, 6.2 by BMWP Score and 11.2 by Expanded Trent Biotic Index. Among a great variety of schemes, we selected three for the class determination. It has been claimed to distinguish well for small changes in water quality. The BMWP and ETBI were chosen because they are easy to use, and ETBI has been used previously in many studies. The mean density of macroinvertebrates differed in the stations ($F= 4.175$, $p< 0.001$) and in seasons, as well ($F= 15.238$, $p<0.001$). The highest mean density in individual organisms was recorded in summer and the lowest in winter. From the seasonal records of stream temperature, pH, dissolved oxygen, hardness, organic matter, chloride, sulphate, phosphate, ammonia nitrogen, nitrate, nitrite and biotic indices a correlation matrix was calculated. Significant correlations were found between temperature and BMWP ($r=0.960$ $p<0.04$), temperature and Chandler score ($r=0.993$ $p<0.007$), temperature and ETBI ($r=0.985$ $p<0.015$), BMWP and Chandler score ($r=0.981$ $p<0.019$), ammonia nitrogen and nitrite ($r=0.982$ $p<0.018$), ammonia nitrogen and nitrate ($r=0.957$ $p<0.043$), organic matter and nitrate ($r=0.998$ $p<0.002$), organic matter and nitrite ($r=0.955$ $p<0.011$), organic matter and hardness ($r=0.944$ $p<0.05$), nitrite and nitrate ($r=0.982$ $p<0.018$), nitrite and phosphate ($r=0.964$ $p<0.036$), phosphate and sulphate ($r=0.951$ $p<0.049$), hardness and chloride ($r=0.945$ $p<0.001$) and a negative correlation between temperature and dissolved oxygen ($r= -0.993$ $p<0.018$). BMWP, Chandler score, ETBI and temperature intercorrelate. Each is tied into a seasonal cycle with the same timing (*e. g.* higher temperatures and higher biotic scores in summer).

Classification of composite samples for the first and second stations showed differences between catchments, based on the presence-absence of taxa. *Heptagania*, *Capnia*, *Perla*, *Dinocras*, *Elmis*, *Paraleptophlebia* and *Hydropsyche* were major indicator species of the first stations, and the physicochemical results were mostly class I for the first stations. *Gammarus* and *Baetis* were major indicator species of the second stations. This will confirm that *Gammarus* and *Baetis* species (except *B. alpinus*) are often dominant and frequent in weakly polluted water. This was confirmed by the chemical results.

Fish richness shows that this part of the stream is not polluted yet (Table 3). Species of *Alburnus* and *Leuciscus* are sensitive to pollution. Species of *Salmonidae* are not found in this study, but the water quality and stream-bed are suitable for *Salmonidae* farming.

Macroinvertebrate species as bioindicators of chemical pollution were determined to the species level and evaluated with the physicochemical parameters used in biomonitoring. The results of physicochemical values were classified by Turkish Standards [20]. The values of the physicochemical parameters and their classes of water quality are given in Table 4.

TABLE 1 - The species of phylum of algae, Sarcodina and Rotifera found in Kelkit stream.

PHYLUM	CLASS	ORDO	FAMILY	GENUS/SPECIES
Chlorophyta	Cholorophyceae	Ulatrichales	Ulatrichaceae	Ulothrix sp
				Ulothrix subtilissima. Rabenhorst.
	Bryopsidophyceae	Cladophorales	Cladophoraceae	*Cladophora sp.*
				Rhizoclonium sp.
	Desmidiales	Zygnematales	Zygnemataceae	*Zygnema sp.*
				Zygnema sterile
				Zygnema tinatum
				Spirogyra sp.
				Spirogyra daedaleoides
				Spirogyra weberi
				Spirogyra micropunctata
				Mougeotia sp.
Cyanophyta	Cyanophyceae	Oscillatoriales	Oscillatoriaceae	*Anabaena sp.*
				Tolypothrix limbata
Chrsophyta	Xantophyta	Heterotrichales	Tribonemataceae	*Vaucheria sp.*
Pyrrophyta	Dinophyceae (Dinoflagellates)	Peridiniales	Ceratiaceae	*Ceratium hirundinella*
Bacillariophyta	Pennatibacillariopyhceae	Pennales	Achanthaceae	*Achnanthes sp.*
				Achnanthes exigua.Grun.
				Achnanthes lanceolata.Grun.
				Asterionalla sp.
				Cocconeis placentula.Ehr.
			Cymbellaceae	*Cymbella sp.*
				Cymbella aflinis. Kütz.
				Cymbella lata. Grun.
				Cymbella turgida.Gregory.
			Fragillariaceae	*Fragillaria sp.*
				Fragillaria intermedia. Grun.
				Synedra sp.
				Synedra acus. Kütz.
				Synedra ulna. Nitzsch
				Tabellaria sp.
			Naviculaceae	*Mastogloia sp.*
				Navicula sp.
				Navicula cryptocephala. Kütz.
				Pinnularia sp.
				Pinnularia biceps. Greg.
				Pinnularia fasciata. Lagerstedt.
				Pinnularia microstauron. Ehr.
Bacillariophyta	Pennatibacillariopyhceae	Pennales	Nitzschiaceae	*Nitzschia sp.*
				Nitzschia acicularis. W.Smith.
				Nitzschia dicephala. W.Smith.
				Nitzschia falaisiensis.Grun.
			Surirellaceae	*Cymatopleura sp.*
				Cymatopleura angulata
				Cymatopleura elliptica. Brebisson
Sarcomastigophora Subfilum:Sarcodina	Superclass:Rhizopoda Lobosea	Amoebaea	Hyalodiscidae	Amoeba proteus. Pallas
				Astramoeba radiosa. Ehrenbergi
				Dinamoeba sp.
				Dinamoeba horrida. Schaeffer
Rotifera	Bdelloidea (Digononta)	Bdelloida	Habrotrochidae	*Habrotrocha sp.*
	Monogononta	Ploima	Dicranophoridae	*Cephanodella sp.*
				Cephanodella auriculata
				Cephanodella euderbyi
				Cephanodella exigua
				Cephanodella megalocephala
			Lecanidae	*Lecane ohioensis*
				Lecane elasma
				Monostyla bulla
			Trichocercidae	*Elosa worallii var.spinifera Wisen.*
				Elosa worallii Lord.

TABLE 2 - Systematic list of taxa of macroinvertebrates found in Niksar stream.

FHYLUM	CLASS	ORDO	FAMILY	GENUS/SPECIES
Platyhelminthes	Turbellaria	Tricladida	Tricladidae	*Polycelis sp.*
Mollusca	Bivalvia	Unionoida	Unnionidae	*Unio pitorum*
		Sphaeriida	Sphaeriidae	*Sphaerium spp*
	Gastropoda	(Superorder) Basommatophora	Planorbidae	*P(Coretus) vornesus*
				P(Tropidiscus) planorbis
Annelida	Clitellata	Hirudina	Glossiphoniidae	*Hellobdella stagnalis*
		Oligochaeta	Lumbriculidae	*L. variegatus*
Crustacea	Malacostraca	Amphigoda	Gammaridae	*Gammarus sp.*
Insects (Sub. Filum Hexapoda	Pterygota	Ephemeroptera	Baetidae	*Baetis sp.*
				Centroptilum pennatulum
			Ephemeridae	*Ephemera sp.*
			Ecdyonuridae	*Heptagenia sp.*
				Ecdyonurus sp
			Leptophlebiidae	*Paraleptophlebia sp.*
		Odonata	Gomphidae	*Gomphus sp.*
			Aeshnidae	*Brachytron sp.*
			Cordulegasteridae	*Cordulegaster sp.*
		Plecoptera	Leuctridae	*Leuctra sp.*
			Capniidae	*Capnia sp.*
			Perlidae	*Perla bipunctata*
				Dinocras cephalotes
		Hemiptera	Corixidae	*Corixa sp.*
				Micronecta sp.
		Trichoptera	Philopotamidae	*Philopotamus sp.*
			Psychomyidae	*Lype sp.*
			Hydropsychidae	*Hyropsyche sp.*
			Glassosomatidae	*Agapetus sp.*
			Hydroptilidae	*Oxyethira sp.*
		Diptera	Tipulidae	*Tipula sp.*
			Dixidae	*Dixa sp.*
			Chaoboridae	*Chaoborus sp.*
			Culicidae	*Culex sp.*
			Simuliidae	*Simulium sp.*
			Chironomidae	*Chironomous sp.*
		Coleoptera	Hygrobiidae	*Hygrobia hermanni*
			Dytiscidae	*Dytiscus sp.*
				Agabus bipustulatus
				Llybius fuliginosus
			Hydrophiliidae	*Hydrophilus piceus*
				Hydrobius fuscipes
			Elminthidae	*Elmis aenea*

TABLE 3 - Systematic list of taxa of fish found in Niksar stream.

PHYLUM	CLASS	ORDO	FAMILY	GENUS/SPECIES	LOCAL NAME
Chordota	Teleostei	Cypriniformes	Cyprinidae	Cyprinus carpio	Pullu Sazan, Çıplak Sazan
				Chalcalburnus chalcoides	Tatlısu Kolyoz Balığı
				Alburnus alburnus	İnci balığı
				Leuciscus cephalus	Tatlısu Kefali
				Capoeta tinca	Karabalık veya Siraz Balığı
		Siluriformes	Siluridae	*Silurus glanis*	Yayın Balığı
		Perciformes	Percidae	*Perca fluviatilis*	Tatlısu Levreği

TABLE 4 - Seasonal mean parameters and the classes of the water quality in the first five and the second five stations of the stream Kelkit.

Parameters	Autumn	Winter	Spring	Summer
Temperature °C	16-15 (I - I)	9-10 (I - I)	15-14 (I - I)	22-22 (I - I)
pH	8.34-8.45 (I - I)	7.76-7.90 (I - I)	8.23-8.32 (I - I)	8.27-8.22 (I - I)
Dissolved oxygen (mg/L)	8.38-9.40 (I - I)	8.96-9.90 (I - I)	9.24-9.44 (I - I)	7.68-7.89 (I - I)
Conductivity (µS/cm)	510-504 (I - I)	480-498 (I - I)	540-572 (I - I)	590-569 (I - I)
Total dissolved solids (mg/L)	726±58-689±40 (I - I)	655±44-670±55 (I - I)	686±39-705±85 (I - I)	842±60-760±50 (I - I)
Hardness (mg $CaCO_3$/L)	160±15-154±20 (I -I)	156±19-170±25 (I - I)	193±10-184±16 (I - I)	240±21-225±14 (I - I)
Organic matter (mg/L)	2.30±0.16-3.18±0.25 (I - I)	2.76±0.24-3.12±0.41 (I - I)	2.92±0.40-3.41±0.37 (I - I)	3.28±0.56-3.70±0.42 (I - I)
Chloride (mg/L)	89.9±7.5-74.3±6.4 (I - I)	109.6±11.8-94.5±8.1 (I - I)	117.5±9.3-102.5±11.7 (I - I)	191.1±16.5-205.8±19.3 (I - II)
Sulphate (mg/L)	70.8±6.4-90.5±10.3 (I - I)	70.6±5.7-86.4±7.8 (I - I)	80.1±9.3-94.3±10.7 (I - I)	63.3±4.2-76.9±8.5 (I - I)
Phosphate (mg/L)	0.96±0.20-0.84±0.32 (IV - IV)	0.22±0.05-0.19±0.08 (II - II)	3.65±0.54-3.86±0.48 (IV - IV)	1.86±0.78-1.98±0.34 (IV - IV)
Ammonia nitrogen (mg/L)	0.77±0.15-0.90±0.23 (I - I)	1.11±0.24-1.25±0.13 (II - II)	1.34±0.35-1.43±0.22 (II - II)	1.50±0.40-1.32±0.19 (II - II)
Nitrate (mg/L)	10.24±1.1-9.15±1.29 (II - II)	10.45±1.86-12.6±1.4 (II - II)	13.57±0.93-15.80±1.21 (II - II)	11.86±1.79-12.70±1.33 (II - II)
Nitrite (mg/L)	0.40±0.07-0.38±0.04 (IV - IV)	0.35±0.05-0.36±0.03 (IV - IV)	0.55±0.06-0.56±0.05 (IV - IV)	0.60±0.09-0.68±0.06 (IV - IV)
Lead (µg/L)	4.62±0.28-5.79±0.21 (I - I)	6.27±0.25-5.84±0.30 (I - I)	4.18±0.13-4.82±0.23 (I - I)	3.94±0.10-4.32±0.26 (I - I)
Cadmium (µg/L)	1.38±0.17-1.50±0.11 (I - I)	2.85±0.20-2.40±0.32 (I - I)	2.47±0.18-2.12±0.13 (I - I)	2.62±0.25-2.45±0.20 (I - I)
Iron (µg/L)	50.5±4.23-65.74±5.4 (I - I)	42.39±3.9-37.6±2.51 (I - I)	85.65±3.01-97.32±4.63 (I - I)	93.45±5.87-99.16±8.38 (I - I)
Copper (µg/L)	5.82±0.32-8.43±0.50 (I - I)	7.65±0.24-6.36±0.48 (I - I)	6.41±0.30-7.73±0.41 (I - I)	6.82±0.38-8.11±0.49 (I - I)
Manganese (µg/L)	14.89±1.2-19.56±2.0 (I - I)	19.7±1.84-17.32±0.9 (I - I)	22.60±1.46-29.88±3.20 (I - I)	29.83±3.26-34.46±3.18 (I - I)
Zinc (µg/L)	0.36±0.05-0.54±0.04 (I - I)	0.72±0.07-0.66±0.05 (I - I)	0.53±0.03-0.68±0.06 (I - I)	0.48±0.04-0.63±0.07 (I - I)
Boron (µg/L)	0.20±0.03-0.34±0.05 (I - I)	0.32±0.02-0.25±0.03 (I - I)	0.75±0.04-0.83±0.06 (I -I)	0.86±0.05-0.77±0.04 (I - I)

I: High quality water, II: weakly polluted water, III: Polluted water, IV: High polluted water
The first values are given referring to the first five station and second values for the second five stations.

TABLE 5
Concentrations of metals determined in some macroinvertebrates, fish and residue samples.

Species	Pb	Cd	Fe	Cu	Mn	Zn
Macroinvertebrates						
Sphaerium spp.	40±5	53±6	12±4	0.5±0.1	0.8±0.1	0.2±0.01
Gammarus sp.	216+30	184±21	49±5	2.1±0.2	2.2±0.2	0.2±0.01
Baetis sp.	170±24	198±35	56±7	2.8±0.1	1.8±0.1	0.4±0.05
Heptagenia sp.	23±4	10±1	8±2	1.1±0.2	-	0.1±0.01
Paraleptophlebia sp.	57±6	36±2	7±0.6	-	1.1±0.2	0.2±0.01
Capnia sp	32±2	42±5	10±2	1.8±0.1	0.9±0.1	-
Perla bipunctata	18±2	11±2	9±1	2.0±0.4	0.7±0.1	0.3±0.02
Dinocras cephalotes	65±10	45±6	16±3	-	1.2±0.2	-
Hyropsyche sp.	86±14	70±6	-	1.3±0.2	0.6±0.1	0.2±0.01
Simulium sp.	38±5	49±8	15±2	0.8±0.3	1.4±0.2	-
Chironomous sp.	204±28	143±32	23±4	2.5±0.2	1.2±0.1	0.5±0.05
Elmis aenea	15±3	28±4	7±0.4	0.9±0.1	-	0.2±0.01
Fish						
Cyprinus carpio	66±8	34±5	11±2	1.4±0.4	1.0±0.1	0.2±0.04
Chalcalburnus chalcoides	45±6	29±3	6±0.3	1.9±0.5	1.5±0.2	0.5±0.08
Alburnus alburnus	84±12	57±9	8±0.5	1.0±0.4	1.9±0.1	0.6±0.05
Leuciscus cephalus	37±5	82±10	18±2	1.2±0.2	0.8±0.1	-
Capoeta tinca	72±9	60±8	14±4	1.6±0.3	1.6±0.2	0.3±0.04
Silurus glanis	25±4	14±3	12±2	0.9±0.1	0.7±0.1	0.2±0.01
Perca fluviatilis	30±6	19±5	9±0.8	1.3±0.2	1.2±0.2	0.4±0.03
Residues						
Agricultural runoff	134±26	120±18	24±3	15±3	9±1	6±0.5
Domestic sewage	105±18	85±12	10±2	12±5	5±0.8	8±0.7
Industrial waste	275±52	200±30	36±4	23±4	8±0.6	10±1

-: not detected
concentrations of Pb and Cd (µg/kg), all others (mg/kg)

All parameters varied in each of the four seasons and stations and were found to be class I except for ammonia nitrogen, nitrate, nitrite and phosphate. Ammonia nitrogen was class II except in autumn, nitrate class II and nitrite class IV in all seasons. The use of fertilizers in agriculture and urban sewage is believed to increase the nitrate and nitrite concentration. In addition, the absence of freshwater plants might cause an increase in nitrogen ion concentrations in the stream. Especially, excess nitrite concentration restricts the life of living organisms. Phosphate was found to be as class II in winter and class IV during the other seasons. The exceeding amounts of phosphate concentration are thought to be mainly a result of the use of dung in agriculture and detergents including phosphate. Trace metal concentrations were determined to be class I. All physicochemical parameters determined in Kelkit stream are in agreement with those earlier reported for Yesilırmak river [16].

The concentrations of trace metals were determined in some macroinvertebrates, fish and residues samples and accumulation factors calculated. The results are given in Table 5. The accumulation of metals changed depending on the species. For example, some species (*Gammarus sp.*, *Baetis sp.* and *Chironomus sp.*) accumulated the metals at high ratios. The minimum and maximum accumulation factors were 3 and 43 for Pb in *Elmis aenea* and *Gammarus sp.,* 4 and 79 for Cd in *Heptagenia sp.* and *Baetis sp.*, 67 and 544 for Fe in *Chalcalburnus chalcoides* and *Baetis sp.*, 83 and 467 for Cu in *Sphaerium spp.* and *Baetis sp.*, 24 and 88 for Mn in *Hyropsyche sp.* and *Gammarus sp.*, 200 and 1200 for Zn in *Heptagenia sp.* and *Alburnus alburnus*, respectively.

Various metal accumulations in biological samples have been made and the values found are in agreement with those reported in the literature [21, 22]. The concentrations of metals in residues (agricultural runoff, domestic sewage and industrial waste) were found to be high, but their dilution in Kelkit stream decreased metal concentrations. Recoveries were nearly quantitative for all elements studied (≥ 95%) with relative standard deviations less than 10%.

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