

Multivariate analysis on the distribution of micro-macro elements and their derivatives at Meriç River (Thrace Region, Turkey)

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ABSTRACT

Meriç River, called international water, is one of the most important river systems in Thrace. As the river is an open ecosystem to intensive anthropogenic impacts from settlements, agricultural and industrial areas, monitoring its aquatic characteristics is very valuable in terms of maintaining its sustainable use. In particular, knowing the micro and macro element contents that play an important role on primary productivity in aquatic ecosystems will be very useful in predicting the eutrophication process. In this study some chemical analyzes (calcium, magnesium, chloride, nitrate nitrogen, nitrite nitrogen, sulphate, phosphate, copper, iron, zinc) were carried out to determine the concentrations and distribution of some micro-macro elements and their derivatives in Meriç River. Thus, it was aimed to determine the micro and macro element contents of different regions in the river, to compare the data with other studies in the region and to make suggestions on the sustainable use of the river. For this aim, samplings were done selected from eight stations located in Meriç River at Thrace region of Turkey between January and December 2011. Chemical analyzes of Ca, Mg, Cl, NO₃-N, NO₂-N, PO₄, SO₄ in water samples taken from the sampling stations by the Ruttner water sampler at monthly intervals were carried out in the laboratory using classical and spectrophotometric methods. The multivariate analysis (Bray-Curtis Cluster Index) was used to evaluate the similarities of sampling stations in terms of seasonal averages of these parameters. In order to determine the concentrations of some heavy metals (Cu, Fe and Zn), water samples taken by Ruttner sampler and sediment samples taken by Ekman grab at seasonal intervals were measured in flame atomic absorption spectrometry. The sampling stations were evaluated also statistically by using Bray-Curtis Cluster Index in terms of heavy metal contents of water and sediment. According to the result of statistical analysis, it was determined that the locations at lower Meriç River area are different from the upper area. Especially it was observed that the sampling locality after Ergene River added to Meriç River has very low quality level in terms of some chemical contents. It is thought that this may be due to the agricultural and industrial pollution load carried by the Ergene River. Therefore, it has been concluded that these locations must be evaluated in the studies of physicochemical evaluation of Meriç River.

Keywords: Meriç River, Nutrients, Water pollution, Environmental parameters, Multivariate analysis



Introduction

The rapid development of various industries, dense pesticide usage, agricultural activities and uncontrollable anthropogenic deposits affect freshwater sources negatively. Over the past years, the harmful effects of water contamination to ecosystem caused by various anthropogenic activities have been discussed from different perspectives. Water resources are often threatened by industrial wastes, mines, and urban and agricultural pollutants that contain materials other than organic contaminants. While some elements cause eutrophication in aquatic ecosystems, the others like heavy metals can be deposited in the sediment. Thus, the usage of water resources becomes limited and the bioaccumulation potential of some heavy metals in aquatic organisms leads to important environmental hazards (Pourkhabbaz, 2018).

Some elements (C, H, O, N, K, P, Mg, S) and their derivatives (nitrite, nitrate, sulphate, phosphate) are necessary for the growth of plants. They are called macro elements and they can enter into aquatic ecosystems in many ways (Çepel, 1996; Bolat & Kara, 2017). Especially nitrogen and phosphorus are necessary for the biochemical cycle but their excessive amounts lead to eutrophication in aquatic ecosystems (Alkan et al., 2013). Also, some elements (Fe, Cl, Cu, Mn, Zn, Mo, B, Ni) are called micro elements. Although these are necessary to aquatic plants, their high concentrations lead to toxic effects (Çepel, 1996; Bolat & Kara, 2017). High concentration levels of micro and macro elements play an important role in pollution of aquatic ecosystems (Webber, 1981; Alkan et al., 2013). Also, some micro elements can accumulate in sediment, lead to deterioration of water quality, and they reach all organisms by the food web (Seven et al., 2018).

The most widely used definition of water quality is that water resources have suitable characteristics on chemical, physical and biological properties for designated usage. Some of the most important chemical characteristics of water are macro and micro elements such as plant nutrients and heavy metals. Plant nutrients such as nitrogen and phosphorus (from agricultural activities such as fertilization and animal feeds) can enter river ecosystems at excessive rates. In addition, industrial and domestic pollutants contribute to the entering of macro and micro elements into the river ecosystem (Thangamalathi & Anuradha, 2018). Inorganic pollutants from these activities are usually substances of mineral origins with metals and their salts (Wong, 2012). Inorganic pollutants as material can be found naturally in ecosystems but anthropogenic activities have been lead to increase their concentrations and numbers in aquatic environments (Thangamalathi & Anuradha, 2018). These inorganic substances also enter the envi-

ronment through, as well as natural processes, different anthropogenic activities such as mine drainage, smelting, metallurgical and chemical processes and they can be toxic due to the accumulation in the food chains (Salomons et al., 1995; Thangamalathi & Anuradha, 2018).

Meriç River is one of the largest rivers in Turkey. Meriç River Basin known as “Evros River” in Greek and “Maritsa River” in Bulgarian is located in Turkey, Greece and Bulgaria. Major tributaries of Meriç River are the rivers Arda (Bulgaria, Greece and Turkey), Tundja-Tunca (Bulgaria and Turkey), Erithropotamos (Bulgaria and Greece), and Ergene (Turkey). Meriç River is called as “International River” because it forms the border between Turkey and Greece; it is also called the “Transboundary River” because it crosses the border between Bulgaria and Turkey (Yanik, 1997). The water of the river is mostly used for agricultural irrigation in the area, while the delta is suitable for fishing (ORSAM, 2011). Unfortunately the increase of industrial activities and intense agricultural applications due to the rapid developments of urbanization in the area has caused lot contaminants to be added to the river. The Ergene River, which is one of the most important tributaries of the Meriç River, flows through settlements, agricultural and industrial areas to the river before joining (Anonymous, 2012). In this study, concentrations of some micro-macro elements and their derivatives along the Meriç River in the Thrace region of Turkey and their local distributions were investigated. For this purpose, while the seasonal averages of Ca, Mg, Cl, NO₃-N, NO₂-N, PO₄, SO₄ analysis in water samples taken from eight locations at monthly intervals in the river were evaluated, heavy metal concentrations (Cu, Fe, Zn) were analysed and evaluated from the samples taken from water and sediment at seasonal intervals from the same locations. While the water and sediment quality levels were evaluated in terms of chemical contents, the obtained results of the chemical analysis were analysed statistically also using multivariate analysis method (Bray-Curtis Cluster Analysis). In addition, the chemical changes in the river over time were evaluated by comparing them with other studies performed in the Meriç River.

Material and Methods

Meriç River starts in Bulgaria and, after forming the Turkey-Greece border it flows in to the Aegean Sea (Figure 1). The Meriç River Basin, including its main tributaries Arda and Tunca that mainly lies in the Bulgarian territory, and Ergene River is added to the basin in the Turkish territory. Meriç River has a drainage area of approximately 52,600 square kilometers (Bulgaria contains 65% of this total area, Greece 87% and Turkey 28%) (UNECE, 2009).

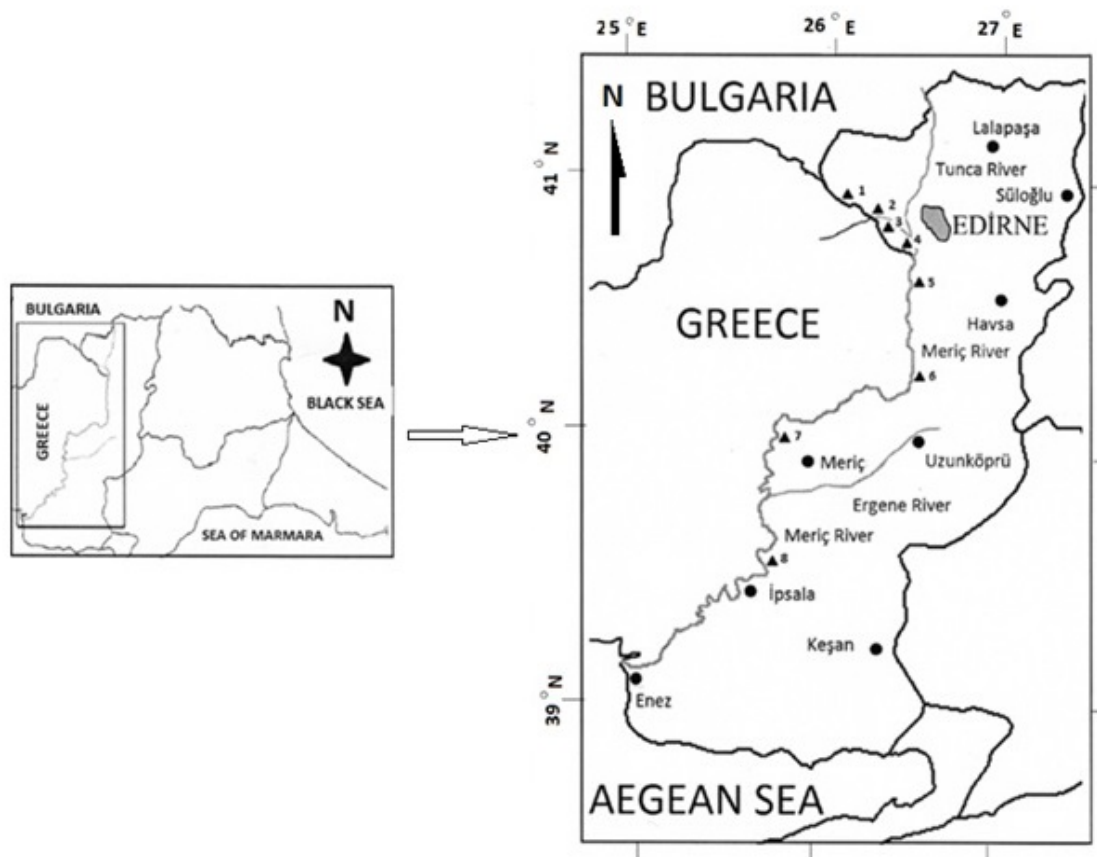


Figure 1. Location of Meriç River and sampling stations

Table 1. Location knowledges of the sampling stations

Station No	Station Knowledge	Coordinates	
1 st	Meriç River enters in to Turkey	41° 42' 59" N	26° 22' 15" E
2 nd	Some industrial facilities area	41° 41' 17" N	26° 24' 56" E
3 rd	Arda River joint Meriç River	41° 39' 89" N	26° 32' 93"E
4 th	Tunca River joint Meriç River	41° 37' 57" N	26° 34' 84 "E
5 th	Tatarköy Village/Agricultural area	41° 34' 69" N	26°35' 83" E
6 th	Saçlımüsellim Village/Agricultural area	41° 25' 17" N	26° 37' 77" E
7 th	İpsala/Agricultural area	41° 14' 99" N	26° 21' 29" E
8 th	Ergene River joint Meriç River	40° 59' 36" N	26° 20' 77" E

In this study, water samples to determine the concentrations of Ca, Mg, Cl, NO₃-N, NO₂-N, PO₄, SO₄ were taken from a total of 8 stations along Meriç River at monthly intervals between January and December 2011. The obtained values for these chemical parameters were used to calculate the seasonal averages used for statistical analyses. In addition, water and sediment samples to determine the concentrations of heavy metals (Cu, Fe, Zn) were taken from the same stations at seasonal intervals. Location knowledge and features of the sampling stations (coordinate details and explanatory information on selected localities) are presented at *Table 1* and the map of the studied area is shown in Figure 1.

At each station, the water samples were taken by Ruttner sampler and put into polyethylene bottles (2 L) and transported to the laboratory to analyse Ca, Mg, Cl, NO₃-N, NO₂-N, SO₄, PO₄ without delay. The analyses were carried out using classical titrimetric or spectrophotometric methods as proposed by Egemen & Sunlu (1999).

Also, for heavy metal analysis, water samples taken by Ruttner sampler and sediment samples taken by Ekman Grab (15x15 cm²) were put into sterile polyethylene bottles (100 cc) and transported to the laboratory with the addition of 0.1 N.HNO₃ to reduce pH levels to below 2. The sediment samples were dried at 105°C (24 hours) in the laboratory before analysis. The water and sediment samples for heavy metal analysis were prepared using the techniques from different literatures to analyse by flame atomic absorption spectrophotometer (Perkin-Elmer A-Analyst 800) in laboratorial conditions (Van Loon, 1980; Welz & Sperling 1999; Karataş et al., 2007).

All obtained results were transformed by LogBase10 in Microsoft Office Excel 2003 and SPSS 9.0 for Windows to use statistical techniques (Krebs, 1999). The heavy metal and the other chemical contents of the sampling locations selected in Meriç River were then compared in the programme BioDiversity Pro 2.0 using Bray-Curtis Cluster Analysis (McAleece et al., 1997).

Results and Discussion

In this study, some chemical analyses were carried out to determine the concentrations of some micro-macro elements and their derivatives at different locations in Meriç River located in the Thrace region of Turkey.

Although the water samples were taken at monthly intervals from the selected eight stations to analyze the concentrations

of calcium, magnesium, chloride, nitrate nitrogen, nitrite nitrogen, sulfate, and phosphate, the seasonal averages of them were evaluated due to their close monthly rates (Table 2). The analyses results of heavy metal concentrations (Cu, Fe, Zn) in the samples of water and sediment taken from the same localities at seasonal intervals are also presented in Table 2.

Hardness is expressed as the total of the concentrations of Ca and Mg ions called macro-elements (Durhasan, 2006). Calcium in freshwater environments can originate from the dissociation of salts such as calcium chloride or calcium sulphate. Most calcium in surface waters comes from streams flowing over limestone, CaCO₃, gypsum, CaSO₄·2H₂O and other calcium-containing rocks and minerals (APHA, 2005). In this study the average calcium values in water samples ranged between 39-78 mg/L. The highest calcium rates in the water samples were generally observed at the 8th station. Magnesium in fresh water is typically present at concentrations ranging from 10-50 mg/L (Hem, 1992). In this study, it was found that the average magnesium values in water samples ranged between 5.9-38.5 mg/L. In previous studies performed in Meriç River, Kalebaşı (1994) reported between 3.006-5.771 mg/L of calcium, Özkan & Çamur-Elipek (2006) reported min.49 - max.69 mg/L calcium and min.16-max.26 mg/L magnesium.

Although chloride ion is a chemical component that can be found in all natural waters, it is generally observed at low concentrations (Hem, 1992). In this study, it was found that the average chloride values in the water samples ranged between 13.6-139.6 mg/L. The chloride values at the 8th station were observed higher than the other stations in all seasonal averages of the water samples (*Table 1*). In previous studies performed in Meriç River, Kalebaşı (1994) reported min.32 - max.128 mg/L of chloride; Özkan & Çamur-Elipek (2006) reported min.36 - max.57 mg/L of chloride; Altınoluk-Mimiroğlu & Çamur-Elipek (2017) reported min. 9.8 - max.1752.7 mg/L of chloride and Tokatlı (2019a) reported 125 mg/L of chloride. When chloride values increase in freshwater, it is called contaminated water (Klee, 1990). According to the Control Regulation of Water Pollution of Turkey (Anonymous, 2016), it was determined that the chloride values in seasonal averages of water samples exceeded fourth water quality level at the 8th station while it was observed at the second quality level in all other sampling stations. The reason for high chloride amounts found at the 8th station where Ergene River joins the Meriç may be that the water comes from Ergene River located on an area of intense industrial activities. Ergene River was reported as one of the rare river ecosystems that is contaminated from the source area (Tokatlı, 2019b). The increase in chloride values in contaminated waters is also supported by the literature (Klee, 1990).

Table 2. The distribution of micro-macro elements and their derivatives in water and sediment samples in the sampling stations.

		Spring Season							
		1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	8 th
Other chemicals	Ca (mg/L)	55.30	53.16	55.57	47.02	53.43	50.76	49.69	60.11
	Mg (mg/L)	5.96	12.74	17.59	15	10.81	11.94	10.97	10.16
	Cl (mg/L)	16.65	17.65	17.65	15.32	25.32	22.99	27.32	91.63
	NO ₂ -N (mg/L)	0.017	0.017	0.018	0.002	0.023	0.015	0.011	0.150
	NO ₃ -N (mg/L)	7.678	6.903	8.634	6.350	7.27	5.90	6.756	6.347
	PO ₄ (mg/L)	0.068	0.075	0.074	0.045	0.064	0.065	0.050	0.062
	SO ₄ (mg/L)	1.511	1.586	1.518	1.389	1.617	1.6	1.41	1.831
Heavy metals	Cu (µg/L)	UAL	UAL	UAL	UAL	UAL	UAL	UAL	UAL
	Fe (µg/L)	152	145	387	95	200	157	77	55
	Zn (µg/L)	122	142	107	125	87	85	100	95
	*Cu (ppm)	UAL	0.46	0.66	1.34	0.14	0.04	2.3	18.2
	*Fe (ppm)	129.54	28.58	56.74	103.52	40.64	34.86	138.74	164.06
	*Zn (ppm)	8.88	3.58	6.84	15.04	5.42	3.78	15.34	7.44
		Summer Season							
Other chemicals	Ca (mg/L)	58.24	58.24	56.91	52.63	49.16	48.89	49.69	45.95
	Mg (mg/L)	16.46	19.04	15.32	17.59	22.27	19.37	15.81	24.37
	Cl (mg/L)	23.32	22.32	21.99	18.32	23.99	27.99	27.32	123.8
	NO ₂ -N (mg/L)	0.016	0.016	0.008	0.0001	0.0001	0.0001	0.0001	0.280
	NO ₃ -N (mg/L)	3.769	4.587	2.992	1.849	1.886	1.593	0.742	0.897
	PO ₄ (mg/L)	0.068	0.064	0.041	0.025	0.036	0.02	0.029	0.058
	SO ₄ (mg/L)	1.931	2.007	2.027	1.808	1.965	1.983	2.114	2.401
Heavy metals	Cu (µg/L)	UAL	UAL	UAL	UAL	UAL	UAL	UAL	UAL
	Fe (µg/L)	70	UAL	52	65	147	162	52	42
	Zn (µg/L)	132	30	47	75	90	145	87	112
	*Cu (ppm)	0.5	UAL	UAL	UAL	0.26	UAL	1.62	UAL
	*Fe (ppm)	103.5	51.0	51.1	87.5	115.8	104.2	155.1	155.2
	*Zn (ppm)	6.3	4.26	5.72	11.58	11.4	9.3	13.48	3.1
		Autumn Season							
Other chemicals	Ca (mg/L)	70.27	68.93	62.52	57.71	59.58	63.59	55.57	78.28
	Mg (mg/L)	19.69	21.31	14.52	22.91	22.43	38.57	24.53	21.62
	Cl (mg/L)	21.99	24.98	18.99	19.99	26.99	62.31	24.99	139.6
	NO ₂ -N (mg/L)	0.0001	0.0001	0.0001	0.0001	0.003	0.137	0.005	0.204
	NO ₃ -N (mg/L)	7.455	4.467	4.801	2.883	3.547	13.35	1.33	3.25
	PO ₄ (mg/L)	0.09	0.08	0.06	0.047	0.064	0.059	0.047	0.088
	SO ₄ (mg/L)	2.657	2.919	2.122	1.965	2.084	2.086	2.099	3.064
Heavy metals	Cu (µg/L)	UAL	UAL	UAL	UAL	UAL	UAL	UAL	UAL
	Fe (µg/L)	30	UAL	40	UAL	41	3	UAL	60
	Zn (µg/L)	117	135	100	140	115	152	202	127
	*Cu (ppm)	UAL	UAL	UAL	UAL	UAL	UAL	UAL	UAL
	*Fe (ppm)	60.38	26	27.32	58.88	36.96	95.78	41.94	146.54
	*Zn (ppm)	5.92	3.76	3.46	6.14	5.02	8.7	3.12	2.54
		Winter Season							
Other chemicals	Ca (mg/L)	54.50	47.55	46.49	39	46.75	48.8	54.77	54.7
	Mg (mg/L)	15.49	17.58	9.03	8.84	11.77	12.90	12.75	15.49
	Cl (mg/L)	22.96	20.62	23.62	13.62	23.29	22.96	29.27	100.28
	NO ₂ -N (mg/L)	0.017	0.017	0.11	0.0001	0.01	0.003	0.009	0.107
	NO ₃ -N (mg/L)	10.12	10.18	6.49	2.44	5.76	7.86	19.95	9.04
	PO ₄ (mg/L)	0.106	0.10	0.13	0.12	0.12	0.061	0.09	0.08
	SO ₄ (mg/L)	1.435	1.499	1.468	0.905	1.371	1.430	1.455	1.647
Heavy metals	Cu (µg/L)	85	47	67	30	92	40	125	150
	Fe (µg/L)	972	692	610	405	625	500	467	675
	Zn (µg/L)	152	215	102	160	460	162	165	152
	*Cu (ppm)	2.28	1.62	0.6	7.52	6.02	1.44	0.88	1.96
	*Fe (ppm)	231.4	106.72	57.02	418.8	321	111.32	103.58	190.44
	*Zn (ppm)	13.12	17.44	5.58	21.1	14.06	9.8	4.48	4.24

*: sediment samples; UAL: Under Analysed Limit

According to the seasonal averages of NO₂-N, NO₃-N, PO₄ and SO₄ ratios in water samples, all sampling stations have changing values, but the concentrations of these parameters have always been high at the 8th station. In this study, it was determined that SO₄, PO₄, NO₃-N values of water have first quality level compared with the values in Anonymous (2016), while NO₂-N values were determined in second and third quality level. In a previous study by Kendirli et al. (2005), nitrogen and phosphorus were reported to be the most important components affecting the water quality of the Ergene and Meriç Rivers. Sulfate in freshwater ecosystems usually comes from rock or soil containing gypsum and other minerals containing sulphate (APHA, 2005). In addition, sulphate can enter aquatic ecosystems by the wastewater discharges of industrial plants and agricultural activities (APHA, 2005). Phosphate compounds can also naturally enter aquatic environments containing rocks. However, anthropogenic contaminants (such as fertilizers, pesticides, detergents and industrial wastes) cause phosphate to enter the running waters (Spellman, 2014). In this study, seasonal average values of SO₄ and PO₄ in the water samples were determined at first class quality level according to the regulation of Anonymous (2016). In previous studies performed in Meriç River, Tokatlı (2015) reported SO₄ between 64.1-120 mg/L; Altınoluk-Mimiroğlu & Çamur-Elipek (2017) reported between 23.68-422.75 mg/L, and Tokatlı (2019a) reported 86 mg/L. In a previous study performed in Meriç River by Tokatlı (2019a) the nitrate values are reported at first quality level while nitrite values are reported at second quality and phosphate values at third quality level. High nitrogen and phosphorus amounts can lead to eutrophication process in aquatic ecosystems and indirectly to change of the other physicochemical features in the water.

Some elements such as Fe, Cu, Zn, Cl, Mn, Mo, B, Ni, called micro elements, are necessary for growth of aquatic plants. Although Fe and Cu elements are necessary for physiological activities in plant cells, high Cu concentrations are toxic to algae and secondary aquatic plants (Yruela, 2005). In this study, some heavy metal concentrations (Cu, Fe, Zn) in Meriç River were analysed in both the water samples and sediment samples. According to this:

In this study, Fe and Zn in spring season in the Meriç River, Zn in summer and autumn seasons, Cu, Fe and Zn in winter season were determined in the water of all sampling stations (Table 2). Fe and Zn values of the water samples were found to have first class quality level (Anonymous, 2016). However, the Cu concentrations in the water samples were ob-

served at winter season only. While Cu values of water samples exceeded second quality level in almost all other sampling stations, it was observed that the rate reached the third water quality level in the 8th station. In the study conducted by Tokatlı (2019a), it was reported that the Cu values in the water samples taken from the Meriç River were found to have first class quality and the Zn values were found to have second class quality. While Fe concentrations in water samples were often observed at first quality level in almost all sampling stations and seasons, it was observed that the rate in the stations exceeded this level at winter season. While Zn concentrations in water samples were often observed at first quality level in almost all sampling stations and seasons, it was observed that the rate in the 5th station reached second level at winter season.

In the sediment samples, Fe and Zn were determined in spring, summer and autumn seasons and Cu, Fe and Zn were determined in winter seasons (Table 2). In this study, the concentrations of these heavy metals in the sediment samples were determined at first quality level (MacDonald et al., 2000). Although the Cu concentrations were observed generally the under analyzed limit, they ranged between 0.04 ppm.-18.2 ppm. The observed concentrations of Fe ranged between 26 - 418.8 ppm; the Zn concentrations were observed between min. 2.54 - max. 17.44 ppm. In a previous study performed in the Ergene River Basin including Meriç River, although the concentrations of Cu and Zn were also measured, chromium and cadmium were reported as the most risky element in sediment of the Ergene River Basin (Tokatlı, 2019b). Also, chromium and nickel elements were found to be the most concerning in terms of biological risk within the region (Tokatlı & Baştatlı, 2016; Tokatlı, 2019b).

Because some heavy metals were found at under analysed limit in a lot of locations, the multivariate analysis was applied to the data of heavy metals and the other chemicals, separately. According to the statistical analysis results for the parameters (except heavy metals) in Table 2, the 8th station was determined to be different from the other sampling stations (Figure 2). There was no statistically significant difference among other sampling stations.

Also, the multivariate analysis was used to analyze the heavy metal findings (Figure 3). It was observed that upper and lower river areas were partially different from each other.

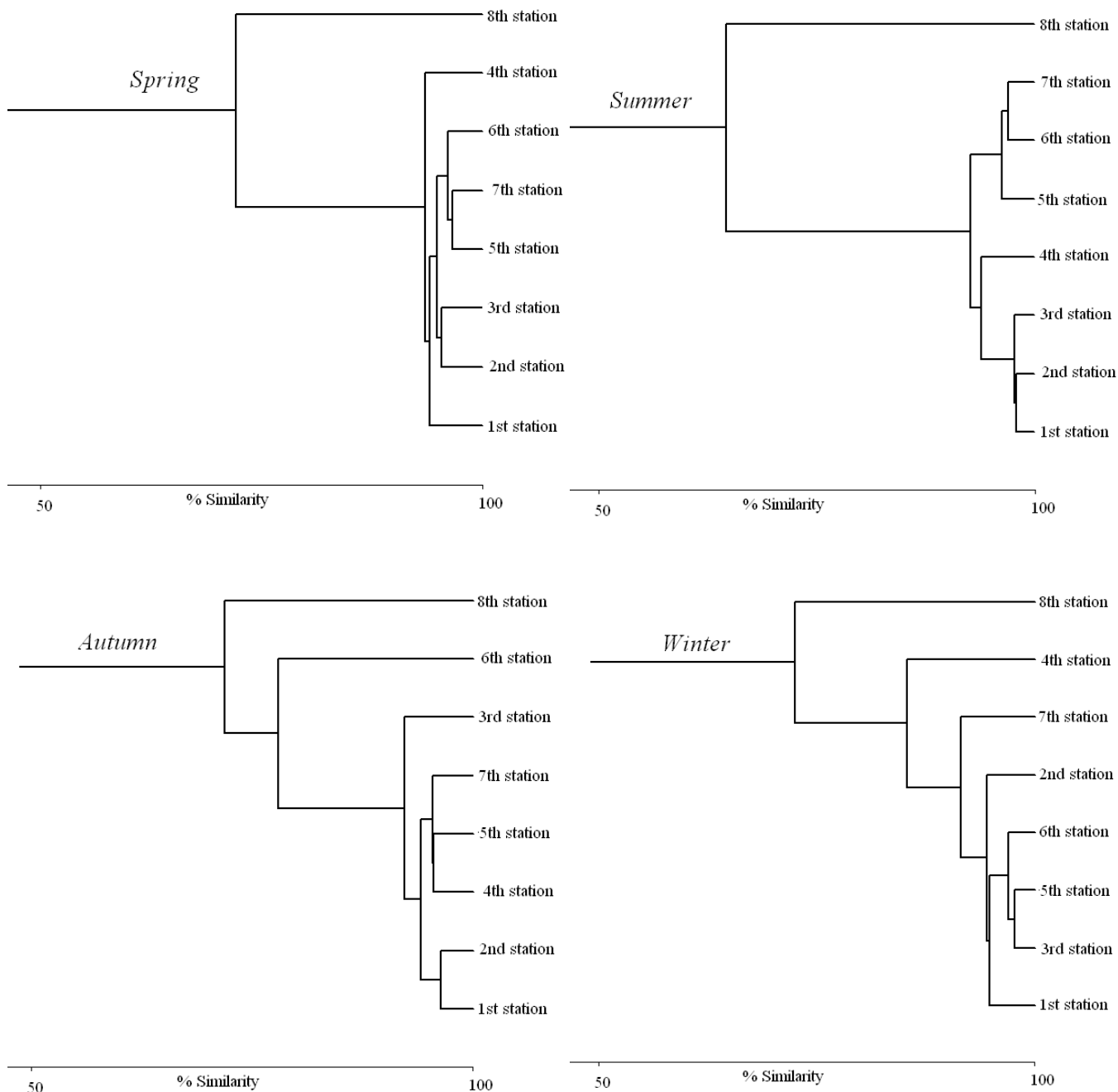


Figure 2. Bray-Curtis Cluster Analyses results of the chemical parameters in water samples.

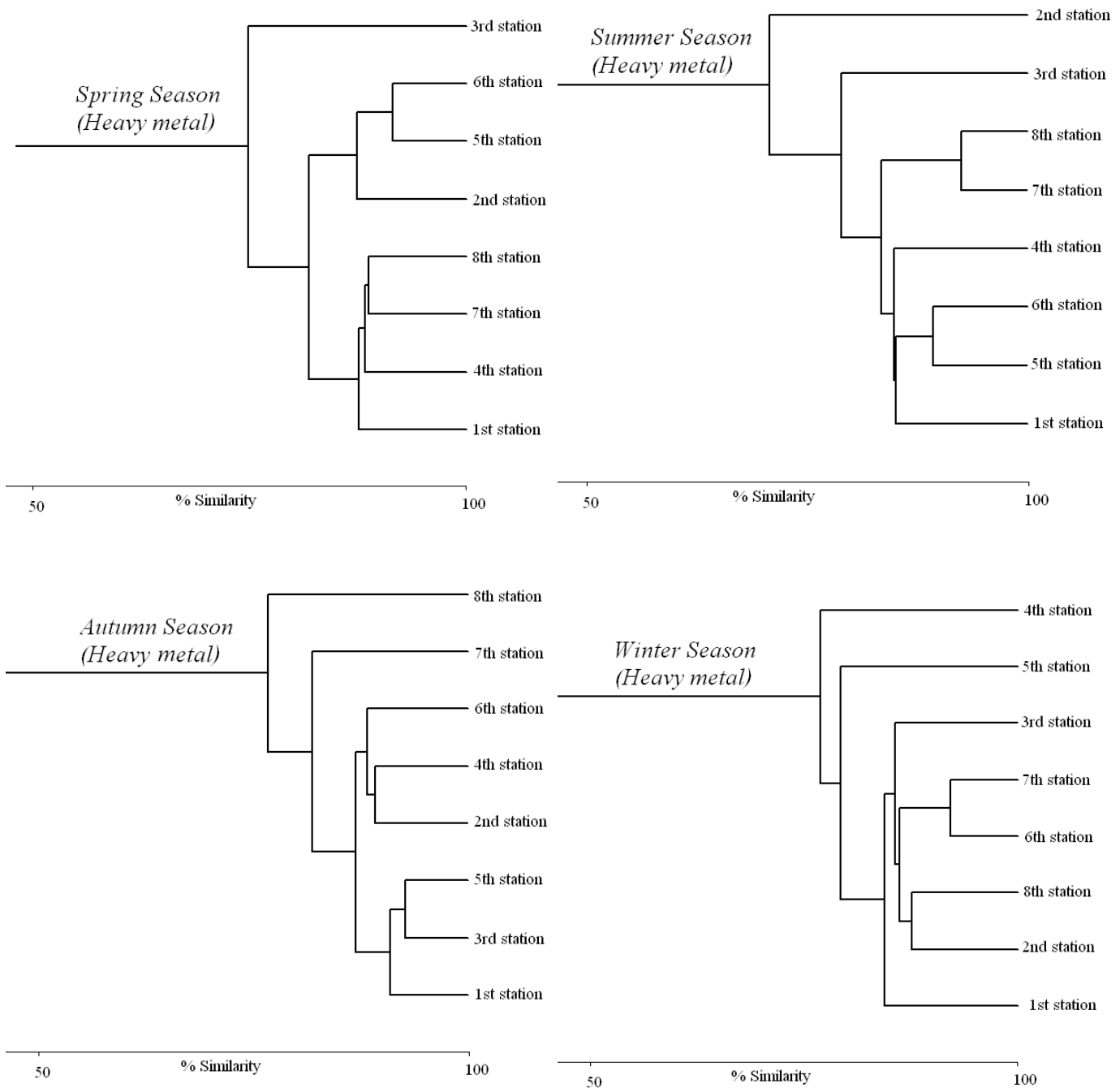


Figure 3. Bray-Curtis Cluster analyses results of the heavy metals in water and sediment samples.

In this study, it was observed that some heavy metal concentrations decreased in summer season. Depending on the chemical structure of the metal, the decrease in the levels of some metals can be caused by the compound formed with other chemicals due to the temperature (Kalyoncu et al., 2016). Also, in this study, the Fe concentrations were determined the most accumulated metal in sediment of the sampling stations. Usero et al. (2003) explained that Fe is abundant in the sediment of aquatic ecosystems because of it being the most abundant metal in the earth's crust. In the summer season, copper was not found in water at some stations (1st, 5th and 7th stations), while it was detected in sediment. While some metals do not detect in water, they can be present in the sediment. This may be related to the sediment particles absorbing the metals in the water and the precipitation of high molecular weight metals to the bottom (Kır et al., 2007). Furthermore, the concentration of heavy metals accumulated in the sediment varies according to the ratio of sediment particles at the bottom, the size of the particles and the presence of organic substances in the sediment (Kır et al., 2007). Our findings in this study support the literature.

Another important risk related to heavy metals is that these substances accumulate in the soil in the long term. One of the most important sources of heavy metal pollution in rivers is soil (sediment) and organic substances mixed with water as a result of soil erosion. Sediment, organic and inorganic substances mixed in the water play an important role in heavy metal amount especially in rainy months (Dökmen, 2000). The reason for the high rate of heavy metal at the 8th station in autumn season can be considered as the mixing of heavy metals in the soil into the Meriç River through the Ergene River.

According to DSI data, while the flow rate of the Ergene river was 2m³/sec until 1995, it has been flowing at an average of 8m³/sec since 1995 due to the increasing groundwaters of industrial or urban usage (Arabacı et al., 2015). Tokatlı (2015) reports that the water quality of Meriç River has decreased significantly after merging with Ergene River. Altınoluk-Mimiroğlu & Çamur-Elipek (2017) pointed out that Meriç River water quality has fallen to the second quality level after it is merged with Ergene River having fourth quality. It was also reported that Meriç Basin is exposed to intensive inorganic pollution and is under the effect of industrial applications sourced from the Ergene Basin (Tokatlı & Başatlı, 2016).

Transport, dissolution, precipitation, complex formation, adsorption and bioaccumulation mechanisms of heavy metals in aquatic environments are quite complex processes and are affected by the physicochemical properties of water (Metin-

Dereli et al., 2017). In this study, the high amount of heavy metal in some sampling stations and low in the other stations can be explained by this situation.

Conclusion

Rivers are dynamic ecosystems whose physical, chemical and biotic characteristics are greatly affected by anthropogenic activities in drainage basins (Moyaka et al., 2004). Lotic ecosystems often react to external and internal variables (Gecheva & Yurukova, 2013).

In this study, it was found that the upper and lower parts of Meriç River are different from each other in terms of some chemical contents. Although the micro-macro elements and their derivatives are necessary for plant growth, high values of them lead to eutrophication in freshwater ecosystems and they have toxic effects to the organisms. In this study, some macro elements and their derivatives were found at high concentrations. Therefore, some precautions should be taken for the sustainable use of the river. Consequently, some suggestions are offered:

- the wastewater should not discharged the river without treatment
- fertilizers should be used at appropriate doses in agricultural areas around the river
- basin management should be provided to manage the river ecosystem
- cross-border cooperations should be provided for the management of the Meriç River Basin and be supported by projects
- water analyses in the basin should be done regularly and changes in water quality should be monitored

Compliance with Ethical Standard

Conflict of interests: The authors declare that for this article they have no actual, potential or perceived conflict of interests.

Ethics committee approval: All authors declare that this study does not include any experiments with human or animal subjects.

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