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Original Research

Assessment of Water Quality in the Meriç River as an Ecosystem Element in Turkey's Thrace Region

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Abstract

The Meriç River is the most important aquatic ecosystem in the Thrace Region of Turkey and the longest river of the Balkans. In the present study, water quality of the Meriç River in the rainy season was investigated and the pressure of the Tunca and Ergene rivers on the system was evaluated by a statistical approach using cluster analysis (CA). Water samples were collected from five stations (two of them from the downstream the Tuna and Ergene and three from the Meriç) in spring 2015. A total of 19 physical, chemical, and biological water quality parameters – including temperature, dissolved oxygen, percentage of oxygen saturation, pH, conductivity, TDS, salinity, turbidity, nitrate, nitrite, ammonium, phosphate, sulfate, chemical oxygen demand, biological oxygen demand, total carbon, total inorganic carbon, total organic carbon, and cyanide – were measured. According to detected data, pollution levels of the investigated rivers were as follows; Ergene River > Tunca > Meriç River. It was also determined that the Ergene and Tunca reduce the water quality of the Meriç significantly after they fall. And also according to the results of CA, three statistically significant clusters were formed, which corresponded to the Ergene (Cluster 1); upstream and midstream of the Meriç (Cluster 2), and downstream of the Meriç and Tunca (Cluster 3).

Keywords: Meriç River, Ergene River, Tunca, water quality, cluster analysis

Introduction

Rapid growth of the world population and the development of industry have caused many environmental problems and decrease the limited freshwater quality of the world. Freshwater pollution has nearly become a limiting factor for humankind and is top of mind all over the globe. Lotic ecosystems are among the most vulnerable freshwater bodies to pollution due to their role in carrying industrial and municipal wastewater and runoff from agricultural lands. Assessment of a large number of limnological water quality data is a significant requirement for effective pollution control and useful freshwater resource management [1-3].

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The Meriç River, 480 km long and with a catchment area of more than 56,000 km^2, is the longest lotic ecosystem of the Balkans. The Meric River Basin covers an area of 32,700 km^2 in Bulgaria, 14,600 km^2 in Turkey, and 8,700 km^2 in Greece. The Meriç flows through Turkish territory on both banks and forms the border between Greece on the west bank and Turkey on the east bank to the Aegean Sea. The lower basin of the Meriç is one of the most productive agricultural lands in Turkey and the system is being used as irrigation water supply. Ninety-five percent of the basin (1,223,263 hectares) is suitable for agriculture and 328,039 hectares of land is suitable for irrigation (technically and economically). Although rice production is occurring in 31 provinces of Turkey, Edirne Province takes first place on paddy production. The Tunca River and the Ergene River,

Table 1. Location properties of select stations.

Station Number	Location	Coordinates		Explanation
		North	South	
S1	Edirne Province	41.66244	26.55151	Upstream of Meriç River
S2	Edirne Province	41.66850	26.55413	Downstream of Tunca River
S3	Boşnak Village	41.62662	26.58105	Midstream of Meriç River (after falling Tunca River)
S4	Uzunköprü District	41.28291	26.69906	Downstream of Ergene River
S5	İpsala District	40.94654	26.36079	Downstream of Meriç River (after falling Ergene River)

which are subjected to strong anthropogenic impacts as they pass through plenty of settlements along industrial enterprises, farms, and areas with intensive agriculture, are its chief tributaries [4-6].

The aim of this study was to evaluate the water quality of the Meriç and to determine the pressure of the Tunca and Ergene on the system by a statistical approach using cluster analysis (CA).

Material and Methods

Study Area and Collection of Samples

Water samples were collected in spring (rainy) 2015 from five stations selected on the lower basin of the Meriç (one of them downstream from the Tunca and one of them downstream of the Ergene) considering the main pollution sources of the system caused from especially Bulgaria, in order to determine the contamination levels and after which point the system is more polluted. Coordinate information, some explanations, and the locations of select stations are given in Table 1 and a map of study area is given in Fig. 1.

Chemical and Physicochemical Analysis

Temperature, DO, percentage of oxygen saturation, pH, EC, TDS, salinity, turbidity, NO_3, NO_2, NH_4, PO_4, SO_4, COD, BOD, TC, TIC, TOC, and CN parameters were selected in order to evaluate the water quality of the system in relation to the expected changes in these selected parameters due to the possibility of predicting water pollution in the Meriç.

Temperature, dissolved oxygen, oxygen saturation, pH, conductivity, TDS, and salinity parameters were determined using a Hach Lange HQ40D Multiparameter device during field studies; turbidity parameter was determined by using a Hach Lange 2100Q Portable Turbiditymeter device; nitrate, nitrite, ammonium, phosphate, sulphate, COD (chemical oxygen demand), TC (total carbon), TIC (total inorganic carbon), and TOC (total organic carbon) parameters were determined using a Hach Lange DR3900 Spectrophotometer device during laboratory studies; the BOD (biological oxygen demand) parameter was determined by using a Hach Lange BOD Trak II device during laboratory studies; and cyanide parameter was determined using a Hach Lange DR890 Colorimeter device during laboratory studies.

Statistical Analysis

Cluster analysis (CA) and similarity and distance index (SDI) according to Bray Curtis were applied to the results using the Past package program.

Results

Water Quality Parameters

Results of detected parameters on the lower basin of the Meriç and some national and international surface and drinking water quality and fish health standards are given in Table 2.

As a result of this study, almost all investigated parameters detected downstream of the Meriç were found to be significantly higher than detected upstream, and Meriç water quality significantly decreased after the Tunca and Ergene. According to detected data, the pollution levels in select stations on the Meriç's lower basin can be classified as upstream of Meriç (S1) > midstream of Meriç (S3) > downstream of Tunca (S2) > downstream of Meriç (S5) > downstream of Ergene.

According to the Water Pollution Control Regulation criteria in Turkey [7], the Meriç lower basin has Class I-II water quality in terms of temperature, pH, TDS, nitrate, sulphate, and cyanide parameters; Class III-IV water quality in terms of the nitrite parameter; and Class IV water quality in terms of TOC parameter. Downstream the Tunca (S2), Ergene (S4), and Meriç (S5) have Class III water quality in terms of BOD parameter and S4 has Class III water quality in terms of COD parameter. It was also determined that S4 has Class IV water quality and S5 has Class III water quality in terms of dissolved oxygen parameter. According to another water quality classification specified by Uslu and Türkman [8], the lower basin of the Meriç has Class IV water quality for the phosphate parameter.

Cluster Analysis (CA) and Similarity and Distance Index (SDI)

Cluster Analysis (CA) and Similarity and Distance Index (SDI), which enable us to classify the objects according to similar characteristics, are two of the most widely used multivariate statistical techniques to evaluate surface water quality [13-17]. In the present application, CA and SDI were used to classify the stations according to physicochemical characteristics. The diagram of CA calculated by using all the detected data are given in Fig. 2, and SDI coefficients of investigated stations are given in Table 3.

According to CA results, three statistically significant clusters were formed with similar water quality characteristics: Cluster 1 (C1) corresponded to station S4, located downstream of the Ergene and classified as a highly contaminated section of the Meriç lower basin; Cluster 2 (C2) corresponded to stations S3 and S1, located on the upper-midstream of the Meriç and classified as a low-contaminated section of the Meriç lower basin; Cluster 3 (C3) corresponded to S2 and S5 stations, located downstream of the Tunca and Meriç and classified as a moderately contaminated section of the Meriç lower basin (Fig. 2). According to the results of SDI, maximum similarity was observed upstream of the Meriç (S1)-midstream of the Meriç (S3) stations at the 0.95 level, and minimum similarity was observed between upstream Meriç (S1)-downstream Ergene (S4) stations at the 0.40 level (Table 3).

Discussion

Most of the 221 industrial enterprises mainly dealing with food and textile production are located in the Meriç lower basin (especially on the Ergene river basin side) and their wastes go directly to the Ergene and Meric. It is also known that in addition to the excessive industrial pressure on the basin, agricultural applications cause significant water pollution problems in the Meriç lower basin. Rice and sunflower are the two main crops produced in the basin and Edirne province is the most important city on rice production in Turkey. The water leached through paddy fields is contaminated by pesticides and fertilizers and reaches the system [18-20].

Fig. 1. Map of the study area.

Table 2. Results of detected parameters and some limit values.

Limit Values and the Results		Parameters																		
		Temp	DO	OS	pH	EC	TDS	Sal	Tur	NO_3	NO_2	NH_4	PO_4	SO_4	COD	BOD	TC	TIC	TOC	CN
		(ºC)	(mg/L)	(%)		(mS/cm)	(mg/L)	0‰	(NTU)	(mg/L)										
Water Quality Classes [7]*	I. Class	25	8	90	6.5-8.5	-	500	-	-	5	0.002	0.2	0.02	200	25	4	-	-	5	0.01
	II. Class	25	6	70	6.5-8.5	-	1,500	-	-	10	0.01	1	0.16	200	50	8	-	-	8	0.05
	III. Class	30	3	40	6.0-9.0	-	5,000	-	-	20	0.05	2	0.65	400	70	20	-	-	10	0.1
	IV. Class	>30	<3	<40	Out of 6.0-9.0	-	>5,000	-	-	>20	>0.05	>2	>0.65	>400	>70	>20	-	-	>12	>0.1
Drinking Water	TS266 [9]	-	-	-	6.5-9.5	2,500	-	-	5	50	0.5	0.5	-	250	-	-	-	-	-	0.05
	EC [10]	-	-	-	6.5-9.5	2,500	-	-	-	50	0.5	0.3	-	250	-	-	-	-	-	0.05
	WHO [11]	-	-	-	-	-	-	-	-	50	0.2	-	-	-	-	-	-	-	-	0.07
Fish Health [12]	Cyprinid Species	28	4	-	6-9	-	-	-	-	-	0.03	0.2	-	-	-	6	-	-	-	-
	Salmonid Species	21.5	6	-	6-9	-	-	-	-	-	0.01	0.04	-	-	-	3	-	-	-	-
Present Study	S1 (Meriç)	20.2 I. Class	8.05 I. Class	92.5 I. Class	8.00 I. Class	386	185 I. Class	0.18	9	1.93 I. Class	**0.031** III. Class	0.018 I. Class	0.650 IV. Class	64.1 I. Class	8.7 I. Class	2.9 I. Class	45.2	28.9	16.3 IV. Class	0.002 I. Class
	S2 (Tunca)	22.1 I. Class	7.67 II. Class	90.9 I. Class	7.99 I. Class	769	380 I. Class	0.38	30	4.22 I. Class	**0.060** IV. Class	0.038 I. Class	1.510 IV. Class	93.2 I. Class	14.2 I. Class	**11.0** III. Class	84.5	60.0	24.5 IV. Class	0.007 I. Class
	S3 (Meriç)	20.6 I. Class	8.02 I. Class	91.9 I. Class	7.90 I. Class	427	205 I. Class	0.20	10	2.24 I. Class	**0.035** III. Class	0.016 I. Class	0.698 IV. Class	66.3 I. Class	10.3 I. Class	3.2 I. Class	48.8	31.7	17.1 IV. Class	0.002 I. Class
	S4 (Ergene)	22.2 I. Class	**1.23** IV. Class	14.1 IV. Class	7.70 I. Class	1,722	864 II. Class	0.88	65	1.00 I. Class	**0.189** IV. Class	**3.220** IV. Class	4.010 IV. Class	120.0 I. Class	53.7 III. Class	**18.0** III. Class	90.0	73.7	16.3 IV. Class	0.014 II. Class
	S5 (Meriç)	21.8 I. Class	5.31 III. Class	61.6 III. Class	7.66 I. Class	680	333 I. Class	0.33	54	2.21 I. Class	**0.147** IV. Class	**0.830** II. Class	3.640 IV. Class	85.8 I. Class	15.2 I. Class	**5.9** III. Class	70.0	39.1	30.9 IV. Class	0.003 I. Class

*According to another water quality classification specified by Uslu and Türkman [8]
Underlined data are not suitable for drinking water
Bold data are not suitable for fish health
Temp – Temperature, DO – Dissolved oxygen, OS – Oxygen saturation, Sal – Salinity, Tur – Turbidity
TS266 – Turkish Standards Institute, EC – European Communities, WHO – World Health Organization

Table 3. SDI coefficients of stations.

	S1	S2	S3	S4	S5
S1	1				
S2	0.70674	1			
S3	**0.95908**	0.74443	1		
S4	**0.40027**	0.64388	0.42923	1	
S5	0.7354	0.91625	0.77518	0.60074	1

Highest and lowest similarities are given in bold.

Nitrite, which is known as an intermediate product in the biological oxidation process reaching from ammonium to nitrate, can reach high concentrations in especially low-oxygen and organically contaminated water. Also, ammonia is known to be found in small amounts in high-oxygen and clean water and organic and inorganic fertilizers, municipal and industrial wastewater discharges are the most important factors on increasing the amount of ammonia and phosphate in water [21, 22]. According to DSI observation reports, nitrogen and phosphorus are the major concerns affecting the water quality of the Ergene and Meric [19]. As similar to reported data by DSI, nitrite, ammonia, and phosphate concentrations waters of the Meriç, Tuna, and Ergene Rivers were detected at very high levels and they have Class III-IV (highly-very highly contaminated) water quality in terms of these parameters [7, 8]. The main reason for the recorded high values of nitrite, ammonia, and phosphate concentrations in Meriç lower basin water is thought to be the runoff from agricultural lands and the sewage discharge from residential areas located in the basin.

Dissolved oxygen is one of the most significant limnological parameters for monitoring the exchange of water quality and aquatic life, and biological oxygen demand (BOD) is an important microbiological parameter, which expresses the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down the organic contents in aquatic ecosystems [21, 22]. According to the EC directives reported by the European Commission in order to protect the health of freshwater fish, dissolved oxygen level in water must be over 4 mg/L for cyprinid species and over 6 mg/L for salmonid species. BOD, nitrite, and ammonia levels in water must be under 6 mg/L, 0.03 mg/L, and 0.2 mg/L for cyprinid species and under 3 mg/L, 0.01 mg/L, and 0.04 mg/L for salmonid species [12]. In the present study, dissolved oxygen, BOD, nitrite, and ammonia levels in Ergene water was recorded as 1.23 mg/L, 18 mg/L, 0.189 mg/L, and 3.220 mg/L, which means that no nektonic organism can live in these extreme conditions – even in the rainy season, when the river discharge volumes increase due to the high precipitation rate and the pollution concentrations are expected to decrease.

The total organic carbon (TOC) parameter is defined as any compound containing carbon atoms (except CO_2). Organic carbon is the energy substrate for many microorganisms and various natural and anthropogenic activities result in the presence of dissolved organic carbon in water. Consumption of organic carbon by microorganisms contributes to the problem of inadequate dissolved oxygen in water bodies, which become a threat to aquatic life [23, 24]. TOC concentrations detected in the Meriç lower basin – even detected upstream – were at significantly high levels, and all the investigated zones of the basin have Class IV

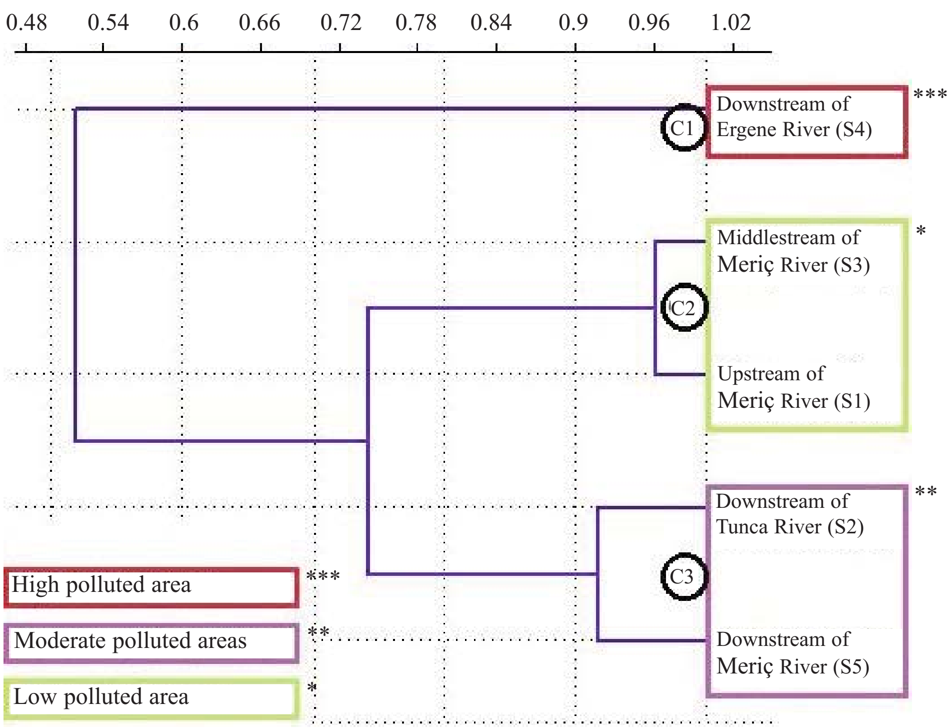

Fig. 2. CA diagram of stations.

(very highly contaminated) water quality in terms of TOC contents [7]. The main synthetic sources of TOC are pesticides, fertilizers, herbicides, and industrial chemicals [25]. Detected higher TOC concentrations in Meriç water than those detected in Ergene water is known as the industrial contamination factor for the system, reflecting that the prime source of TOC in water of the Meriç lower basin could be agricultural applications.

Conclusions

In the present study, Meriç lower basin water quality, including the Tunca and Ergene rivers, was evaluated by investigating physical, chemical, and biological parameters in the rainy season, and some multistatistical methods were applied to detected data in order to classify the basin zones according to water quality characteristics.

According to detected data, the pressure of the Tunca and Ergene on the system was clearly presented and the pollution levels of the investigated rivers were recorded as Ergene > Tunca > Meriç. According to data observed, nitrite, phosphate, and TOC concentrations in water of the basin were detected at significantly high levels and exceed critical limit values.

Cluster analysis (CA) applied to the results was grouped in five different sections detected on the basin into three clusters of similar water quality characteristics; upper-midstream of the Meriç formed a cluster (C2) as the lowest polluted sections, downstream of the Meriç and Tuncas formed a cluster (C3) as moderately polluted sections, and the Ergene formed a separate cluster (C1) as the most polluted section.

The detected data clearly reveal that agricultural runoff caused from intensive fertilizer applications on especially paddy fields around the rivers, municipal sewage water caused from settlement areas located on the basin, and the industrial discharges by means of especially the Ergene are the main pollution sources for the Meriç lower basin.

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