Water Quality of Havsa Stream Basin Creeks (Thrace Region, Turkey)

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Abstract: Havsa Stream is located on north − west part of Marmara Region and it is one of the most important branches of Ergene River. As many aquatic habitat Havsa Stream is also under effect of an intensive agricultural pressure. In this study, water quality of Süloğlu, Hasköy, Aşağıova, Havsa, Kuleli and Anadere Creeks that are the significant components of Havsa Steam Basin were investigated. Water samples were collected in spring season of 2016 and total of 13 water quality parameters (pH, conductivity, TDS, salinity, turbidity, nitrate, nitrite, phosphate, sulfate, biological oxygen demand, total carbon, total inorganic carbon and total organic carbon) were investigated. Also Cluster Analysis (CA) was applied to detected data in order to classify the creeks in terms of pollution levels. According to detected data, pollution levels of the investigated creeks in parallel to the flow directions as follows; Süloğlu > Hasköy > Aşağıova > Havsa > Kuleli > Anadere in general. According to the results of CA, 3 statistically significant clusters were formed, which were corresponded to Süloğlu and Hasköy (Cluster 1) that were located on the upstream; Kuleli, Havsa and Aşağıova (Cluster 2) that were located on the middlestream; Anadere (Cluster 3) that was located on the downstream.

Keywords: Süloğlu, Hasköy, Aşağıova, Havsa, Kuleli, Anadere, Creeks, Water Quality.

1. Introduction

Developments of industry and rapid growth of population cause lots of environmental problems and they are decreasing the limited usable freshwater potential of the world and mankind. It is known that lotic ecosystems play an important role as a receiving environment for many pollutants. Therefore water quality

monitoring of these aquatic ecosystems help to assess the contamination sources of the systems and provide an effective management of these significant freshwater resources [1-5].

The Meriç River with a length of about 500 km is the longest river ecosystem of the Balkans. The Ergene River, which is known as the chief tributary of Meriç River Basin, is subjected to strong anthropogenic impacts as it passes through plenty of settlement areas, along industrial enterprises, farms and areas with intensive agriculture. The creeks of Havsa Stream Basin are one of the most important

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branches of Ergene River. Intense agricultural applications and settlement areas located on the basin are known as the main pollution factors for the Havsa Stream Basin [5-7].

The aim of this study was to evaluate the water quality of Havsa Stream Basin creeks by determining some limnologic parameters including pH, electrical conductivity (EC), total dissolved solid (TDS), salinity, turbidity, Nitrate nitrogen (NO_3), nitrite nitrogen (NO_2), sulphate (SO_4), phosphate (PO_4), total carbon (TC), total inorganic carbon (TIC), total organic carbon (TOC) and biological oxygen demand (BOD) and classify the creeks according to water quality statuses by using Cluster Analysis (CA).

2. Materials and methods

2.1. Study area and collection of samples

The study area and selected stations on the Havsa Stream Basin are given in Figure 1. Coordinate information, some explanations and the localities of selected stations are given in Table 1. Water samples (one sample per location) were collected in spring season of 2016.

Table 1. Location properties of selected stations

Station Number	Locality	Main Pollution Source [8]	Coordinates		Name of Creek
			North	South	
1. St.	Süloğlu District	Urban Sewage	41.781437	26.916385	Süloğlu
2. St.	Arpaç Village	Agricultural drainage	41.691578	26.881502	Hasköy
3. St.	Havsa District	Urban Sewage	41.548334	26.824100	Aşağıova
4. St.	Tahal Village	Agricultural drainage	41.426217	26.851837	Havsa
5. St.	Kuştepe Village	Agricultural drainage	41.368404	26.959886	Kuleli
6. St.	Input of Ergene River	Agricultural drainage	41.344102	26.883712	Anadere

2.2. Physicochemical analysis

Measurements of pH, electrical conductivity (EC), total dissolved solid (TDS) and salinity parameters were performed by using Hach branded (HQ40D) Portable Multi – Parameter Measurement Device and turbidity parameter was performed by using Hach branded (2100Q) Portable Turbidimeter Device during the field studies. Nitrate nitrogen (NO_3), nitrite nitrogen (NO_2), sulphate (SO_4), phosphate (PO_4), total carbon (TC), total inorganic carbon (TIC) and total organic carbon (TOC) parameters were performed by using Hach branded (DR3900) Spectrophotometer Device and biological oxygen demand (BOD) parameter was performed by using Hach branded (BOD Trak II) BOD Device during the laboratory studies [9-15].

2.3. Statistical analysis

Bray Curtis similarity is a non – metric coefficient particularly common in ecology for the quantitative and qualitative standardized variables. Cluster Analysis (CA) with the paired group algorithm according to Bray Curtis, which was applied in order to classify the investigated streams according to water quality characteristics, and Similarity and Distance Index (SDI) according to Bray Curtis, which was applied in order to determine the similarity coefficients of streams, were applied to detected data by using PAST statistical packed program. All the investigated psychochemical data were used by entering the software at the same time [16].
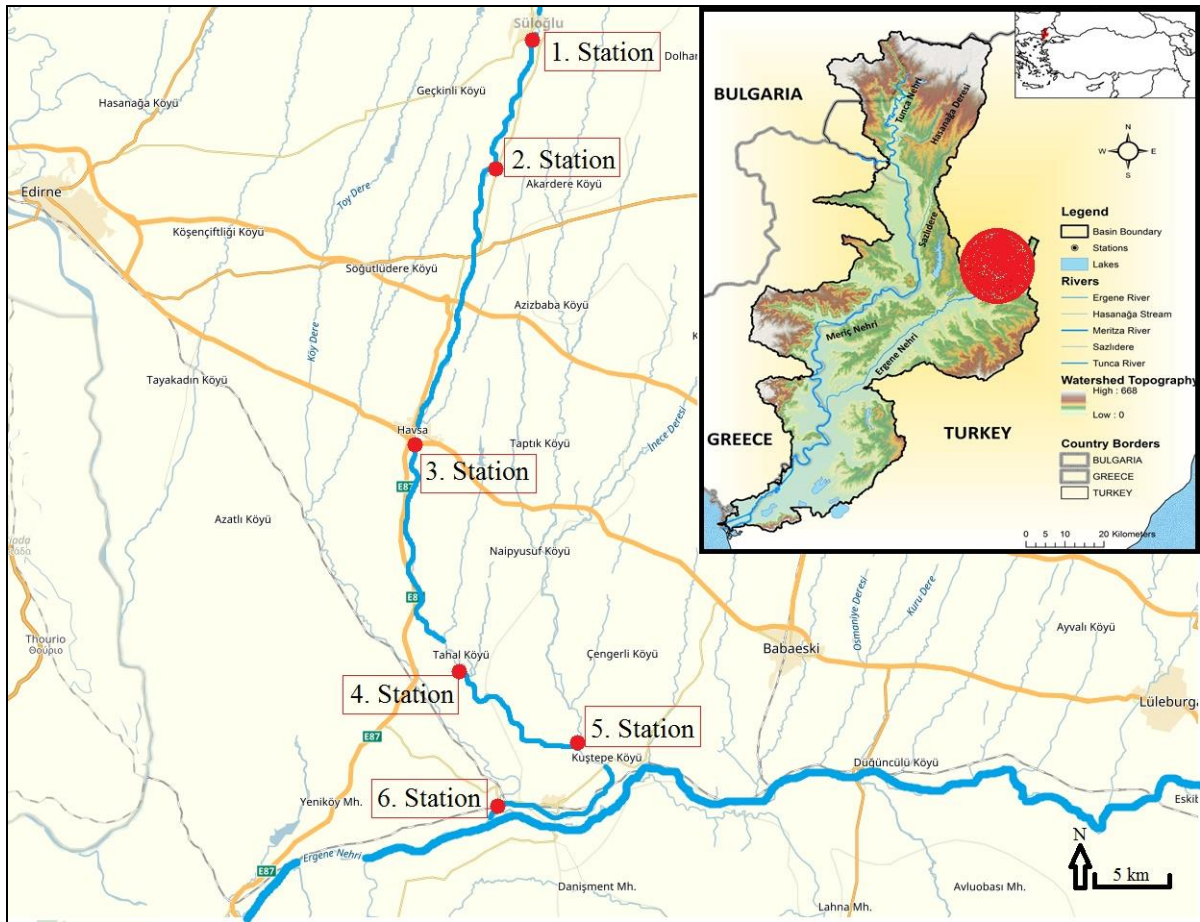
Figure 1. Havsa Stream and selected stations.

3. Result and discussion

The detected water quality parameters in Havsa Stream Basin creeks and some national – international limit values are given in Table 1.

Most ecosystems are sensitive to changes in pH and the monitoring of this parameter has been incorporated into the environmental laws of many industrialized countries. Extreme changes in pH values in surface water can be indicative of an industrial contamination [17]. Havsa Stream Basin has an alkaline water characteristics in general and pH data in water of investigated stations were recorded between the values of 8.01 (in Kuleli Creek) – 8.29 (in Süloğlu Creek). According to the Turkish Regulations, the basin has I. Class water quality in terms of pH values and any investigated stations did not exceed the drinking water and fish health limits [18-21].

Electrical Conductivity (EC) is the normalized measure of the ability of water to conduct electric current in natural waters. This is mostly influenced by dissolved salts like sodium chloride and potassium chloride [17]. The highest EC value in Havsa Stream Basin was recorded in Anadere Creek as 742 µs/cm. According to the Turkish Regulations, the basin has I. Class water quality in terms of EC values and any investigated stations did not exceed the drinking water limits [18-21].

Table 1. Results of detected parameters and some limit values

Limit Values and the Results of Present Study		pH	EC (mS/cm)	[a]TDS (mg/L)	Salinity (‰)	Tur (NTU)	NO$_3$ (mg/L)	NO$_2$ (mg/L)	SO$_4$ (mg/L)	[b]PO$_4$ (mg/L)	TC (mg/L)	TIC (mg/L)	TOC (mg/L)	BOD (mg/L)
*Turkish Regulations Water Quality Classes [18]	I. Class (Very Clean)	6.5-8.5	400	500	-	-	5	0.002	200	0.02	-	-	5	4
	II. Class (Less Contaminated)	6.5-8.5	1000	1500	-	-	10	0.01	200	0.16	-	-	8	8
	III. Class (Much Contaminated)	6.0-9.0	3000	5000	-	-	20	0.05	400	0.65	-	-	12	20
	IV. Class (Extremely Contaminated)	Out of 6.0-9.0	>3000	>5000	-	-	>20	>0.05	>400	>0.65	-	-	>12	>20
Drinking Water Standards	TS266 [19]	6.5-9.5	2500	-	-	5	50	0.5	250	-	-	-	-	-
	EC [21]	6.5-9.5	2500	-	-	-	50	0.5	250	-	-	-	-	-
	WHO [26]	-	-	-	-	-	50	0.2	-	-	-	-	-	-
EC Fish Health Standards [20]	EC/C (Cyprinides)	6-9		25	-	-	-	0.03	-	-	-	-	-	6
	EC/S (Salmonides)	6-9	-	25	-	-	-	0.01	-	-	-	-	-	3
Havsa Stream Basin Creeks	Süloğlu (1. St.)	8.29 I. Class	310 I. Class	148 I. Class	0.15	4.73	0.9 I. Class	0.004 II. Class	19 I. Class	0.75 IV. Class	23.4	21.1	2.32 I. Class	27 IV. Class
	Hasköy (2. St.)	8.28 I. Class	315 I. Class	151 I. Class	0.16	25.8	1 I. Class	0.006 II. Class	22 I. Class	0.13 II. Class	25.3	22.6	2.72 I. Class	4.7 II. Class
	Aşağıova (3. St.)	8.27 I. Class	339 I. Class	162 I. Class	0.16	53.5	0.4 I. Class	0.001 I. Class	22 I. Class	0.82 IV. Class	26.3	22.6	2.72 I. Class	5.3 II. Class
	Havsa (4. St.)	8.03 I. Class	340 I. Class	163 I. Class	0.16	54.8	0.8 I. Class	0.061 IV. Class	24 I. Class	0.78 IV. Class	26.2	25.4	0.763 I. Class	9.8 III. Class
	Kuleli (5. St.)	8.01 I. Class	364 I. Class	175 I. Class	0.17	44.6	1.3 I. Class	0.012 III. Class	22 I. Class	0.95 IV. Class	28.3	27.4	0.954 I. Class	5.2 II. Class
	Anadere (6. St.)	8.24 I. Class	742 I. Class	362 I. Class	0.36	28.3	1.2 I. Class	0.042 III. Class	88 I. Class	0.3 III. Class	43	40.2	2.78 I. Class	4.3 II. Class

[a]Turkish Regulations, 2004 [24]; [b]Uslu and Türkman, 1987 [25]; *III. – IV. Class water qualities are given in bold
TS266 – Turkish Standards Instıtute; EC – European Communities; WHO – World Health Organization

Total Dissolved Solids (TDS), which is defined as the quantity of dissolved material in water, depends mainly on the solubility of rocks and soils that the water contacts. Also salinity is defined as the total of all salts dissolved in water. It is known that settlement sewage wastes and irrigation practices in agricultural applications could raise the levels of TDS and salinity because of the presence of phosphate and nitrate [5, 22, 23]. The highest TDS and salinity levels were determined in Anadere Creek as 362 mg/L and 0.36 %$_0$. Although all the investigated stations have I. Class water quality in terms of TDS values [24], the recorded TDS and salinity levels in the downstream were significantly higher that detected in the upstream. Also all the detected TDS levels in all creeks were significantly higher than the limits reported for the fish health [20].

According to the Water Pollution Control Regulation criteria in Turkey [18], Havsa Stream Basin creeks have I. Class water quality in terms of nitrate, sulphate and TOC parameters and nitrate and sulphate concentrations in water of the basin did not exceed the drinking water limits [19, 21]. But nitrite and phosphate contents in water of Havsa Stream Basin creeks were recorded in very high levels. Upstream stations have II. – III. Class and downstream stations have III. – IV. Class water quality in terms of nitrite parameter and the entire basin has III. – IV. Class water quality in terms of phosphate parameter in general [18, 25]. Also the detected nitrite levels in downstream were significantly higher than the limit values reported for the fish health [20]. Nitrite is known as an intermediate product in the biological oxidation process reaching from ammonium to nitrate. It can reach to high concentrations in especially organically polluted waters. Also organic and inorganic fertilizers and settlement wastewater discharges are the most important factors on the amount of phosphate [5, 22, 23].

Biological Oxygen Demand (BOD) is known as a significant microbiologic parameter.

It helps to expresses the amount of dissolved oxygen needed by aerobic biological organisms to break down the organic materials in aquatic systems [5, 22, 23]. According to the EC directives reported by the European Commission in order to protect the health of fishes in freshwater, BOD levels in freshwater must be under 6 mg/L for cyprinid species and must be under 3 mg/L for salmonid species [20]. In this study, BOD values in water of the entire basin were significantly higher than the limit values specified for salmonides and in water of Süloğlu (IV. Class water quality) – Havsa (III. Class water quality) creeks were significantly higher than the limit values specified for cyprinides [18, 20].

Cluster Analysis (CA) is a significant group of multivariate statistical techniques and it is widely used in environmental pollution studies in order to classify the investigated areas. Hierarchical agglomerative clustering that provides intuitive similarity relationships between any one sample and the entire data set is one of the most common approaches in CA. It is typically illustrated by a dendrogram in order to provide visual summaries of the clustering processes [27-29].

CA with the paired group algorithm was used was applied to detected data to classify the creeks according to water quality characteristics. The diagram of CA calculated by using all the investigated psychochemical data was given in Figure 2. According to the results of CA, three statistically significant clusters were formed: Cluster 1 (C1) corresponded to Süloğlu and Hasköy creeks that were located on the upstream; Cluster 2 (C2) corresponded to Kuleli, Havsa and Aşağıova creeks that were located on the middlestream; Cluster 3 (C3) corresponded to Anadere creek that was located on the downstream. Maximum similarity was observed between Aşağıova and Havsa creeks (98%) and minimum similarity was observed between Süloğlu and Anadere creeks (57%) (Table 2).
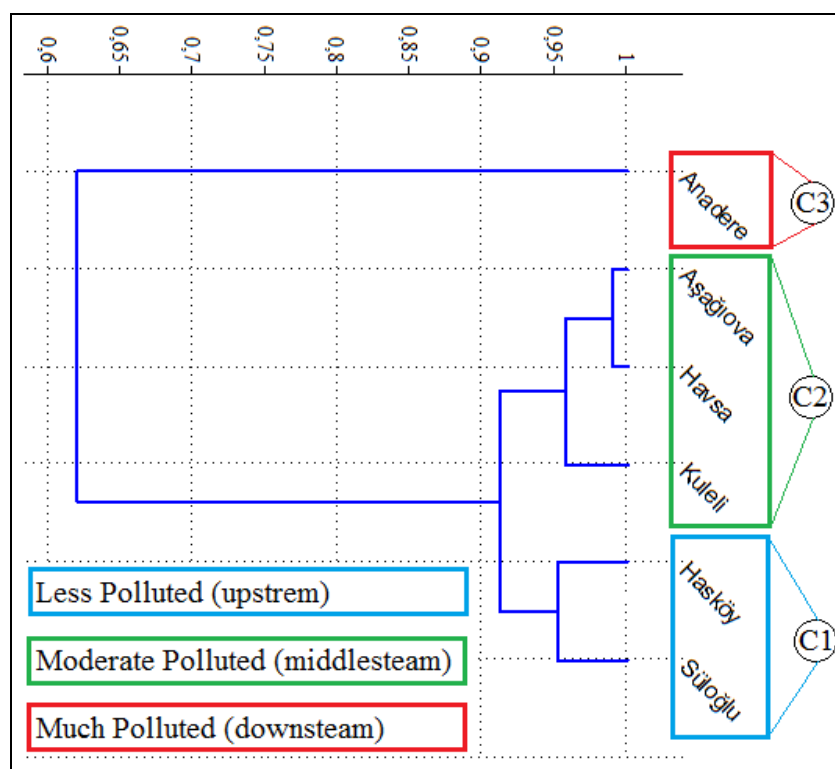
Figure 2. Diagram of CA.

Table 2. Similarity coefficients of investigated creeks

*	Süloğlu	Hasköy	Aşağıova	Havsa	Kuleli	Anadere
Süloğlu	1					
Hasköy	0.95185	1				
Aşağıova	0.90135	0.94652	1			
Havsa	0.8966	0.93728	0.9897	1		
Kuleli	0.87409	0.91789	0.95691	0.95805	1	
Anadere	0.5762	0.60873	0.62771	0.63011	0.66043	1

* Highest and lowest similarities are given in bold

Havsa Stream is one of the most important branches of Ergene River that is also one of the most important branches of Meriç River. Ergene River is known as a dramatically contaminated lotic ecosystem and one of the most polluted basin of Turkey [30-34]. According to the Meriç – Ergene Basin Conservation Action Plan made by Turkish Ministry of Environment and Forestry, General Directorate of Environmental Management in 2008, Havsa Stream is being adversely effected by the domestic waste sourced from especially the settlement areas around the basin, by the industrial waste sourced from especially the organized industrial zones located on the basin and by the agricultural activities conducted almost all around the region. In parallel with the literature, the results of this study show that organic contents of the system are continuous to increase and water quality of the system in

terms of especially nitrogenous and phosphorus compounds is continuous to decrease.

4. Conclusion

In this study, water quality of Havsa Stream Basin creeks were evaluated by investigating some limnologic parameters. As a result of this study, it can be concluded that Havsa Stream Basin is under effect of a significant agricultural pollution and this situation cause to reduce the water quality of the system. In order to provide the sustainability of these aquatic ecosystems in terms of availability by local people, organic contents including mainly nitrite and phosphate concentrations of the creeks originated from agricultural applications must be taken under control by especially a conscious fertilizer application.

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Chất lượng nước của lưu vực đầm lầy Havsa (Vùng Thrace, Thổ Nhĩ Kỳ)

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Tóm tắt: Dòng Havsa nằm ở phía Tây bắc của vùng Marmara và là một trong những nhánh quan trọng nhất của sông Ergene. Bởi vì có rất nhiều sinh cảnh dưới nước nên dòng Havsa cũng chịu ảnh hưởng của áp lực nông nghiệp thâm canh. Trong nghiên cứu này, chất lượng nước của vùng Süloğlu, Hasköy, Aşağıova, Havsa, Kuleli và Anadere Creeks là hợp phần quan trọng của lưu vực Havsa cũng

được điều tra. Các mẫu nước được thu thập vào mùa xuân năm 2016 và tổng số 13 tham số chất lượng nước (pH, độ dẫn, TDS, độ mặn, độ đục, nitrat, nitrit, phosphate, sulfat, nhu cầu oxy sinh học, tổng carbon, carbon vô cơ tổng hợp và carbon hữu cơ tổng hợp) đã được nghiên cứu. Phân tích nhóm cũng được sử dụng để phát hiện dữ liệu, phân loại các lạch về mức độ ô nhiễm. Theo số liệu điều tra, mức độ ô nhiễm của các dòng sông được điều tra song song với hướng dòng chảy như sau; Süloğlu> Hasköy> Aşağıova> Havsa> Kuleli> Anadere nói chung. Theo kết quả phân tích nhóm, 3 nhóm có ý nghĩa thống kê đã được hình thành, tương ứng với Süloğlu và Hasköy (nhóm 1) nằm ở thượng nguồn; Kuleli, Havsa và Aşağıova (nhóm 2) nằm ở trung nguồn; Anadere (nhóm 3) nằm ở hạ nguồn.

Từ khoá: Süloğlu, Hasköy, Aşağıova, Havsa, Kuleli, Anadere, Creeks, chất lượng nước.