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Investigation of water quality of the Şenkale stream feeding the Bahçecik dam meeting the drinking water needs of Gümüşhane province

Gümüşhane ili içme su ihtiyacını karşılayan Bahçecik barajını besleyen Şenkale deresinin su kalitesinin araştırılması

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Abstract
In this study, the drinking water quality of the Şenkale stream was researched. Firstly, water samples were taken from Şenkale stream every month in 2016, 2017, and 2018. The water quality parameters such as temperature, pH, color, electrical conductivity (EC), dissolved oxygen (DO), chemical oxygen demand (COD), total organic carbon (TOC), biochemical oxygen demand (BOD_5), suspended solid matter (SSM), nitrogen group, anion groups, phosphorus group, oil and grease, cation groups, methylene blue active matter (MBAM), hydrocarbons, cyanide (CN^-), phenols, polycyclic aromatic hydrocarbons (PAH), heavy metals and total pesticides were analyzed under the international standards. Hazen's statistical method was used in the analysis of the data. The water quality of Şenkale stream was classified by the Regulation on the Quality and Purification of Drinking Water Supply (RQPDWS) and Regulation Amending the Regulation on Surface Water Quality (RARSWQ). According to RQPDWS; PAH and Fe are in the A2 quality class. $NO^{-}{}_{3}$, F^-, SO_4^{-2}, Cl^- , o-$PO4^{-3}$, CN^- , Pesticide, Al, Mn, Se, Cu, Zn, B, Co, Ni, As, Cd, Cr, Pb, Hg and Ba are in the A1 quality class. According to RARSWQ; TKN and o-PO_4^{-3} are in between I.-II. quality class standards. NO^{-3}, F^- , Mn and Se are in I. quality class. CN^-, PAH, Pesticide, Zn, B, Co, Ni, As, Cd, Pb, Hg and Ba are in the below the maximum environmental quality system value. Al, Fe and Cu are in the above the maximum environmental quality system value.

Keywords: Bahçecik dam, Gümüşhane, Hazen method, Şenkale stream, Water resources

Öz
Bu çalışmada Şenkale deresi içme suyu kalitesi araştırılmıştır. İlk olarak 2016, 2017 ve 2018 yıllarında Şenkale deresinden her ay su numuneleri alınmıştır. Uluslararası standartlar altında Sıcaklık, pH, renk, elektriksel iletkenlik (EC), çözünmüş oksijen (DO), kimyasal oksijen ihtiyacı (COD), toplam organik karbon (TOC), biyokimyasal oksijen ihtiyacı (BOD_5), askıda katı madde (SSM), azot grubu, anyon grupları, fosfor grubu, yağ ve gres, katyon grupları, metilen mavisi aktif madde (MBAM), hidrokarbonlar, siyanür CN^-, fenoller, polisiklik aromatik hidrokarbonlar (PAH), ağır metaller ve toplam pestisit analizleri yapılmıştır. Veri analizinde Hazen istatistiksel yöntemi kullanılmıştır. Şenkale deresinin su kalitesi, İçme Suyu Temin Edilen Suların Kalitesi Ve Arıtılması Hakkında Yönetmelik (RQPDWS) ve Yerüstü Su Kalitesi Yönetmeliğinde Değişiklik Yapılmasına Dair Yönetmelik (RARSWQ) ile sınıflandırılmıştır. RQPDWS'ye göre; PAH ve Fe, A2 kalite sınıfındadır. NO^{-3}, F^- , SO_4^{-2}, Cl- , o-PO_4^- , CN^- , Pestisit, Al, Mn, Se, Cu, Zn, B, C, Ni, As, Cd, Cr, Pb, Hg ve Ba, A1 kalite sınıfındadır. RARSWQ' ya göre; TKN ve o-PO_4^{-3}, I-II kalite sınıfı standartları arasındadır. NO^{-3}, F^- , Mn ve Se I. kalite sınıfındadır. CN^-, PAH, Pestisit, Zn, B, Co, Ni, As, Cd, Pb, Hg ve Ba, maksimum çevresel kalite sistem değerinin altında bulunmaktadır. Al, Fe ve Cu, maksimum çevresel kalite sistem değerinin üzerindedir.

***Anahtar kelimeler**: Bahçecik barajı, Gümüşhane, Hazen yöntemi, Şenkale deresi, Su kaynakları*

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1. Introduction

1. Giriş

Water is a colorless, flavourless and odourless molecule ensuring all organisms' biological life and activities. While 97,5% of the water found on earth is salty water, 2,5 % comprises fresh water (Gürü & Yalçın, 2010). Of this freshwater, 90% is held at the poles and as groundwater, indicating just the low amount of quality water available (T.C. Kalkınma Bakanlığı, 2012). Water is vital for food and drinks to sustain human life and suitable living conditions. However, one of the most significant problems in the next century is predicted to be water scarcity. Water scarcity is related to the ratio between usable water and the population (Rijsberman, 2006).

It can be said that all water resources on earth are not pure. The clean water that comes out of its natural source is directly or indirectly affected by the effects of the pollutants they encounter. Water is vital to the existence and survival of all living organisms (Organization, 2017). Natural water bodies such as rivers, streams, lakes and reservoirs are among the natural resources that provide drinking and utility water to the people of developed and developing countries (Kızıloğlu et al., 2007). However, this valuable resource is increasingly affected by pollution (Hynes et al., 2020). Pollution can be caused by nature or by human anthropogenic activities (Kuşlu et al., 2005). Although the chemical properties of water define its quality, it differs according to the water source from which it is taken. Water characteristics also vary from region to region, depending on the climate and geological structure. Being an underground and surface source of the location where the water is supplied significantly affects the water quality, and the characteristics of the geological structures from which it is taken also affect the chemical contents of the water (Duru et al., 2013; Kolawole et al., 2011; Korkut et al., 2021).

The water issue has been on the agenda of the world public opinion and many international and national organizations, including the United Nations, in recent years. This situation is the difficulties caused by the needs that cannot be met due to the increasing need for water, and it is thought that a water crisis will occur in many countries after the next 2050s. Since the quality of water used by people is among the factors that ensure the protection of life, it is important to determine the quality of underground and surface water resources and to inform users (Manache & Melching, 2004). Although it is in a continuous cycle, it is consumed before completing its cycle due to reasons such as population growth, environmental pollution, cost, unconscious water consumption, change in climatic conditions. Today and in the future, water scarcity is one of the biggest problems for mankind. Finding new water resources for countries has become increasingly difficult (Organization, 2017).

The Falkenmark indicator, an identifier of water scarcity, is the most widely used indicator that considers regions in terms of water potential. This indicator classifies regions according to water status and uses rations as those without water distress, with water distress, arid and excessively arid. When the annual renewable water requirements per person fall below 1700 m^3, water stress is experienced. At values below 1000 m^3, water scarcity is experienced, and at 500 m^3, absolute scarcity is experienced (Falkenmark et al., 1989).

When the current status of water resources in Turkey is assessed, the available water amount per person is 1519 m^3. The Turkish Statistical Institute (TÜİK) states that when the population reaches 100 million, the amount of water per person will fall to 1120 m^3/year, and Turkey will become water-poor (Öktem & Aksoy, 2014).

Currently, the management of water resources has become more comprehensive. In previous times, the location and amount of water resources were considered. In contrast, now the investigation of water quality has come to the agenda, and it is unavoidable to consider this in an integrated way (Rehber, 2012). The 2000/60/EC Water Framework Directive (WFD) followed by European Union (EU) countries appears to be essential for our country to manage water resources with higher quality and more reliability (Rehber, 2012). As a result, the Surficial Water Quality Management Regulation published in 2012 takes precautions in determining and classifying resources integrated with water quality, examines amounts, determines water use purposes, and access the status of good and quality water. This regulation was changed to the 'Regulation Amending the Regulation on Surface Water Quality (RARSWQ)' in 2021. According to general chemical and physicochemical parameters, there are quality criteria for continental surface water resources (Tarım ve Orman Bakanlığı, 2021). Accordingly, water is categorized as very good, good, moderate and poor. Additionally, as a result of analyses according to the Regulation on the Quality and Purification of Drinking Water Supply (RQPDWS), resources are divided into A1, A2 and A3 water quality classes (Tarım ve Orman Bakanlığı, 2021).

In a study, Bayram et al. investigated how the municipality of Gümüşhane, located in the Black Sea region of Turkey, affects the Harşit River, from which municipal wastewater is discharged, in terms of surface water quality. Monitoring and sampling studies were carried out from three different regions every 15 days from March 2009 to February 2010. As a result of the analyzes made, it was determined that t, pH, DO and EC values showed less variation compared to other parameter values (Bayram et al., 2013). In another study, a long-term study was conducted over a period of 52 weeks between the spring of 2004 and the winter of 2005 to characterize the solid waste flow in Gümüşhane Municipality. In this study, the percentage and specific gravity of municipal solid waste components, composting parameters, organic matter content, calorific value and heavy metal concentrations (Cd, Cr, Cu, Ni) were investigated (Nas & Bayram, 2008).

This study examined the Şenkale stream to provide drinking water in Gümüşhane province. It aimed to determine quality criteria according to class based on general chemical and physicochemical parameters and assess suitability in obtaining drinking water in Turkish legislation revised according to the WFD. With this aim, water samples were taken from the Şenkale stream each month in 2016, 2017 and 2018 and analyzed using standard methods with international validity. The results were investigated in terms of Turkish legislation and regulations, and recommendations were made to achieve better water quality (Oskay, 2019).

The project area and surroundings comprise a transition point between Eastern Anatolia and the Black Sea region. Bahçecik dam is located on the Şenkale stream in Kocapınar locale in Bahçecik village in central Gümüşhane and the project location is between 40° 27' 40" - 40° 29' 54" north latitude. Gümüşhane town is located at 1100-1200 m elevation in the narrow valley of the Harşit River, extending 8-10 km with height not exceeding 500 m on a sloped and rocky area. The urban plan for the town shows a minimum elevation of 1105 m and a maximum elevation of 1455 m. The general layout plan is shown in Fig. 1.

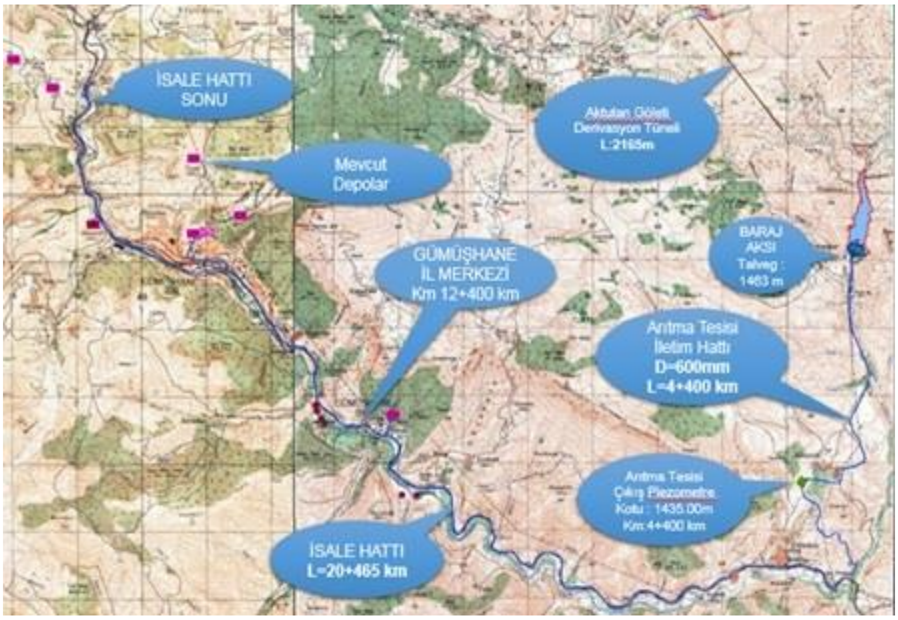

Figure 1. The general layout plan
Şekil 1. *Genel yerleşim planı*

As seen in Fig. 1, the Trabzon-Iran transit road parallel to the Harşit River passes the river, sometimes on the right and sometimes on the left in a northwest-southeast direction. The settlement area north of the Harşit River is more extensive, with settlements extending toward the slope. The layout plan for Bahçecik dam is shown in Fig. 2.

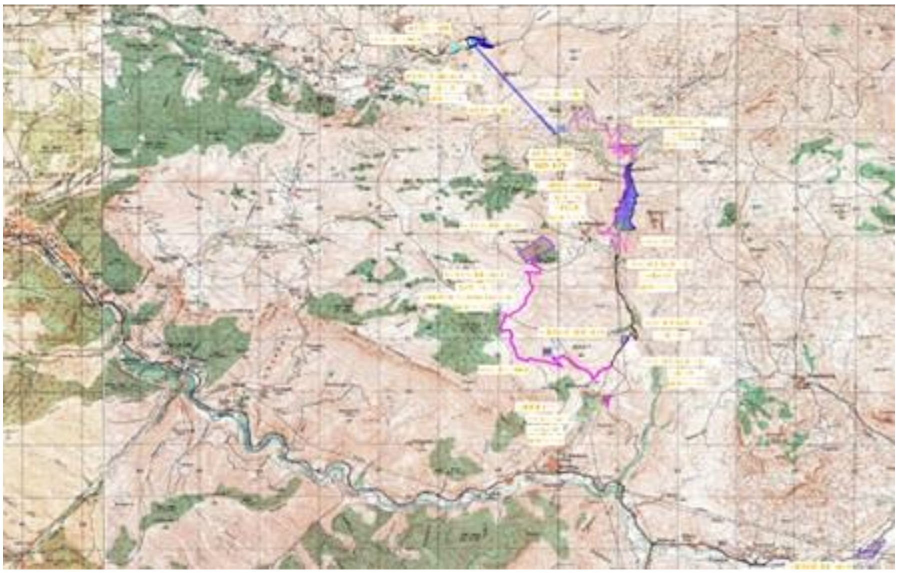

Figure 2. The layout plan for Bahçecik dam
Şekil 2. *Bahçecik barajı yerleşim planı*

Gümüşhane province is located in the Eastern Black Sea region and has excellent potential for aquaculture production in many rivers, lakes and dams. The total surface area of dams and lakes in the province is 745.3 hectares (Aydın, 2014).

In Bahçecik village, Kocapınar locale, 14 km from Gümüşhane town, a dam with 1463 m thalweg, 1485 m minimum water level, 1522 m average water level and 3.04 hm^3 active storage volume with cylinder-compressed cement body was planned on the Şenkale stream. Şenkale stream forming Bahçecik dam lake is a tributary of the Harşit River. The upstream part is called Kazanpınarı stream, and the downstream region is called Kocapınar Stream. Şenkale stream rises on the slope of Kaskara Hill with 2387 m elevation and flows in a southerly direction. Şenkale stream comprises the upstream part of the Bahçecik dam lake.

2. Material and method
2. Materyal ve yöntem

2.1. Regulation on the quality and purification of drinking water supply
2.1. İçme suyu temin edilen suların kalitesi ve arıtılması hakkında yönetmelik

The primary aim of this regulation, published in the Official Gazette numbered 28338 on 29 June 2012, was to determine the basis and quality criteria for surface water resources where drinking water is obtained or planned to be obtained and to identify necessary treatment classes to be implemented to use this water (Tarım ve Orman Bakanlığı, 2019). This regulation encompasses the characteristic features, treatment classes to be implemented according to the category of the water, sampling for parameters that should be monitored in these waters and the analysis frequency and quality categories of surface water resources used to obtain drinking water, or planned for use to obtain drinking water.

According to mandatory and guideline values for all parameters in the water quality standards, water resources are divided into A1, A2, and A3. The following treatment classes are determined for each category

A1: Drinkable water with simple physical treatment and disinfection
A2: Drinkable water with physical treatment, chemical treatment and disinfection.
A3: Drinkable water with physical and chemical treatment, advanced treatment and disinfection
K: guideline value: Values that should be abided by for surface waters providing drinking and use water, or planned for this purpose, separately determined for A1, A2 and A3 categories
Z: mandatory value: represents maximum permissible values for surface waters providing drinking and use water, or planned for this purpose, separately determined for A1, A2 and A3 categories (Tarım ve Orman Bakanlığı, 2019). Water quality standards according to categories are given in Table 1.

Table 1. Water quality standards according to categories (Tarım ve Orman Bakanlığı, 2019)
***Tablo 1**. Kategorilere göre su kalite standartları (Tarım ve Orman Bakanlığı, 2019)*

No	Water Quality Categories / Parameters	A1 K	A1 Z	A2 K	A2 Z	A3 K	A3 Z
1	pH	6.5- 8.5		5.5-9		5.5-9	
2	Color (Pt-Co)	10	20 (İ)	50	100 (İ)	50	200(İ)
3	Total suspended solid matter (SSM) (mg/L)	25					
4	Temperature (°C)	22	25 (İ)	22	25 (İ)	22	25 (İ)
5	Conductivity (20°C) (µS/cm)	1000		1000		1000	
6	Ssmell (dilution factor at 25°C)	3		10		20	
7	NO_3^- (mg NO_3/L)	25	50 (İ)		50 (İ)		50 (İ)
8	F^- (mg F/L)	0.7-1	1.5	0.7-1.7		0.7-1.7	
9	Al (mg Al/L)	0.3		0.3		1	
10	Fe (mg Fe/L)	0.1	0.3	1	2	1	
11	Mn (mg Mn/L)	0.05		0.1		1	
12	Cu (mg Cu/L)	0.02	0.05(İ)	0.05		1	
13	Zn (mg Zn/L)	0.5	3	1	5	1	5
14	B (mg B/L)	1		1		1	
15	Co (mg Co/L)	0.01		0.02		0.2	
16	Ni (mg Ni/L)	0.02		0.05		0.2	
17	As mg As/L	0.01	0.05		0.05	0.05	0.1
18	Cd (mg Cd/L)	0.001	0.005	0.001	0.005	0.001	0.005
19	Total Cr (mg Cr/L)		0.05		0.05		0.05
20	Pb (mg Pb/L)		0.05		0.05		0.05
21	Se (mg Se/L)		0.01		0.01		0.01
22	Hg (mg Hg/L)	0.0005	0.001	0.0005	0.001	0.0005	0.001
23	Ba (mg Ba/L)		0.1		1		1
24	CN^- (mg Cn/L)		0.05		0.05		0.05
25	SO_4^{-2} (mg SO_4/L)	150	250	150	250 (İ)	150	250 (İ)
26	Cl^- (mg CI/L)	200		200		200	
27	Methylene Blue Active Matter (MBAM) (mg MBAM/L)	0.2		0.2		0.5	
28	Reactive phosphorus (Orthophosphate and easily hydrolyzable condensed phosphorus) (mgP/L)	0.4		0.7		0.7	
29	Phenols (mg C_6H_5OH/L)		0.001	0.001	0.005	0.01	0.1
30	Hydrocarbons (mg/L)		0.05		0.2	0.5	1
31	Polycyclic aromatic hydrocarbons (PAH) (mg/L)		0.0002		0.0002		0.001
32	Total pesticides (mg/L)		0.001		0.0025		0.005
33	Chemical oxygen demand (COD) (mg O_2/L)	15		30		40	
34	Dissolved Oxygen Saturation Ratio (%)	>70		>50		>30	
35	Biochemical oxygen demand (BOD_5) (mg O_2/L)	<3		<5		<7	
36	Total Kjeldahl Nitrogen (TKN) (mg/L)	1		2		3	
37	NH_3-N (mg N/L)	0.05		1	1.5	2	4(İ)
38	Total organic carbon (TOC) (mg C/L)	5		8		12	

2.2. Percentage calculation and Hazen method in the directive

2.2. Yönetmelikteki yüzdelik değer hesabı ve Hazen yöntemi

Parameters of Hazen method is shown in Table 2. When calculating the percentage values. with differences in formulae related to data numbers linked to this statistical method. The arithmetic mean was taken for data numbering less than 10, and the category was determined.

Table 2. Parameters of Hazen method
Tablo 2. Hazen yöntemi parametreleri

Method	Percentage fraction	Percentage value	Minimum data number
Hazen	$p = \frac{r - \frac{1}{2}}{n}$	$P = 100.\left(\frac{n - \frac{1}{2}}{n}\right) = 100 - \frac{50}{n}$	10

(r: Serial number from smallest to largest p: Percentage fraction P: Percentage value n: Data number

2.3. Process steps for the Hazen method

2.3. Hazen yönteminin basamakları

1. List water quality data from lowest to highest
2. Percentage fraction (p) and rank number (r) are calculated

Percentage fraction:

$$P = p / 100 \quad (1)$$

Rank number:

$$r = p * n + 1/2 \quad (2)$$

2.4. The supply, preservation and storage conditions of water samples

2.4. Su numunelerinin temini, muhafazası ve saklama koşulları

Sampling points from Şenkale stream in the study can be seen in Fig. 3. Water samples were taken for each month in the years 2016-2017-2018 from three different points shown in Fig. 3. These samples were analyzed and mean values were found. Thus, the analysis studies were carried out within the confidence interval.

Sampling is the essential stage of the process. It is necessary to abide by standards, procedures and directives for the sample to represent the region. It is necessary to assess points where samples are taken in terms of water quality and minimize negative factors during sampling. Action should be taken by evaluating factors like the suitability of sample containers, using the same method for the same point, and taking care accessing the sample point by taking necessary precautions related to weather conditions.

Figure 3. Sampling points from Şenkale stream

Şekil 3. *Şenkale deresinden örnek alım noktaları*

When sampling, the "Instructions for Control, Acceptance, Storage and Disposal of Samples" published by the State Hydraulic Works and standards for parameters like use of sample containers suitable for analysis type, the volume of samples, preservation and storage conditions (duration, acidity, temperature) should be met (TS EN ISO 5667-1 2022; TS EN ISO 5667-3, 2018).

Table 3, shows the supply, preservation and storage conditions of water samples in this study. At the points where the samples were taken, maximum attention was paid to environmental safety.

Attention has been paid to whether there is any pollution in the environment, whether there is human or industrial pollution. Sampling points were determined by considering the conditions that will affect the pollution.

The sampling points were taken from the places where the flow is, from a certain surface and depth. Dark-colored sample containers are made of glass or plastic (PE) bottles, which are protective against losses such as adsorption or evaporation.

Parameters such as temperature, pH, DO, EC from the samples we have taken have been checked in situ and their instantaneous changes have been observed.

Table 3. The supply, preservation and storage conditions of water samples in this study (Oskay, 2019; TS EN ISO 5667-1 2022; TS EN ISO 5667-3, 2018)

Tablo 3. *Su numunelerinin temini, muhafazası ve saklama koşulları (Oskay, 2019; TS EN ISO 5667-1 2022; TS EN ISO 5667-3, 2018)*

Analysis	**Sample container**	**Sample Volume per Unit (mL)**	**Preservation and Storage Conditions Before Analysis**
Temperature	-	-	looked at in the field environment.
pH	-	-	looked at in the field environment.
EC	-	-	looked at in the field environment.
DO	-	-	looked at in the field environment.
Color	Plastic or Glass	300	It is stored in an Unlighted Environment at 4±2°C, preventing contact with air.
SSM	Plastic or Glass	100	Without light, at 1-5°C, preferably 4 hours, acidification with HNO_3 pH 3±0.5
COD	Plastic or Glass	50	Acidification of pH≤2 with H_2SO_4
BOD_5	Plastic or Glass	300	No Light, 4°C or below, 24 hours
Smell	-	-	-
Nitrogen Group (TN, TKN, Organic nitrogen, NH_3-N, NH_4-N, NO_3^--N, NO_2^--N)	Plastic or Glass	50	Acidification at 4°C, 24 hours, pH 1-2 with H_2SO_4
TOC	Plastic or Glass	50	Adjustment to pH approx. 2 with H_3PO_4 at 2-5 °C within 7 days
Phosphate and Phosphorus	Glass	50	At 4°C, 24 hours
CN^-	Plastic or Glass	50	pH>12 with NaOH and cold and lightless environment
Anions (Fluoride, Chloride, Sulphate)	Plastic or Glass	50	No light, at 2-8°C, 24 hours
Oil and Grease	Glass	1000	pH<2 acidification with 1:1 HCl or 1:1 H_2SO_4 and storage at 4°C
Surfactans (MMAM)	Glass	50	At 4°C, 24 hours
Phenols	Dark glass	1000	At 4°C, 24 hours
Hydrocarbons	Dark glass	1000	At 4°C, 24 hours
PAH	Dark glass	1000	Acidification to pH ≤2 with 6N HCl, at 4°C, 24 hours
Pesticides	Dark glass	1000	Acidification to pH ≤2 with 6N HCl, at 4°C, 24 hours
Heavy Metals (Al, Fe, Mn, Se, Cu, Zn, B, Co, Ni, As, Cd, Cr, Pb, Hg, Ba	Plastic	250	Acidification at 4°C to pH below 2 with 1:1 HNO_3, 6 months storage (1 month for Fe and Hg)

It has been preserved according to the storage conditions of each parameter, taking into account factors such as acidification (pH<2), preventing contact with air, opaque environment, and time. The samples taken were immediately analyzed at the accredited State Hydraulic Works 22nd Regional Directorate, Quality Control and Laboratory Branch Office.

Devices used for parameter measurements in the study are given in Table 4.

Table 4. Devices used for parameter measurements in the study
Tablo 4. *Çalışmada parametrelerin ölçümleri için kullanılan cihazlar*

Analysis Name	Devices used
Temperature, pH, EC, DO	WTW Multi 3420i Measuring Device
Color	Hach Lange 5000 UV-VİS Spectrophotometer Device
SSM, COD, BOD_5	Laboratory Equipment
TN, TKN	Ion chromatography in a spectrophotometer device
NO_3^-, F^- , SO_4^{-2}, Cl^- , NH_4, NH_4-N, NH_3-N	Ion Chromatography Device (Anyon) Metrohm 882 Compact IC Plus Brand
TOC	Teledyne Tekmar Brand Total Organic Carbon Determination Device
o-PO_4^{-3}	Spectrophotometer Device
Oil and Grease	Wilks Intracal 2 Device
MBAM , (C_6H_5OH)	Skalar Brand Autoanalyzer Device
CN^-	Kit test, Hach Lange LCK 315
Hydrocarbons	Agilent 7890A GC-MS
PAH	Agilent 1200 Series Brand HPLC
Total Pesticides	Agilent 7890A GC-MS Gas Chromatography Mass Spectrometry
Heavy Metals	Bruker Aurora M90 ICP-MS

3. Research results
3. Araştırma sonuçları

Data for 2016, 2017 and 2018 obtained from analyses in the laboratory for each parameter are given in Figures 4-11. According to national water regulations and the Hazen method, one of the statistical methods included in these regulations, results were assessed in the 95% confidence interval and given as graphs.

3.1. Temperature
3.1. Sıcaklık

Temperature change graph for Şenkale stream in 2016, 2017 and 2018 by monthly is given in Fig. 4. Temperature measurements were performed 3 times during sampling, and the averages were calculated. The temperature values for the Şenkale stream were assessed monthly in 2016, 2017 and 2018, and water quality values were found using the Hazen method and transferred to graphs. As shown in the Şenkale stream temperature graph in Fig. 4, the water quality value (Xr=21.23 ℃) was 95% of the limit value. This limit value was exceeded in August 2017 (23.40 °C) and August 2018 (21.50 °C). Additionally, in seasonal conditions, the temperature values were low in the winter months and high in the summer months. Water quality value based on the Hazen method according to the RQPDWS was A1 water quality class. No classification assessment could be performed according to the RARSWQ.

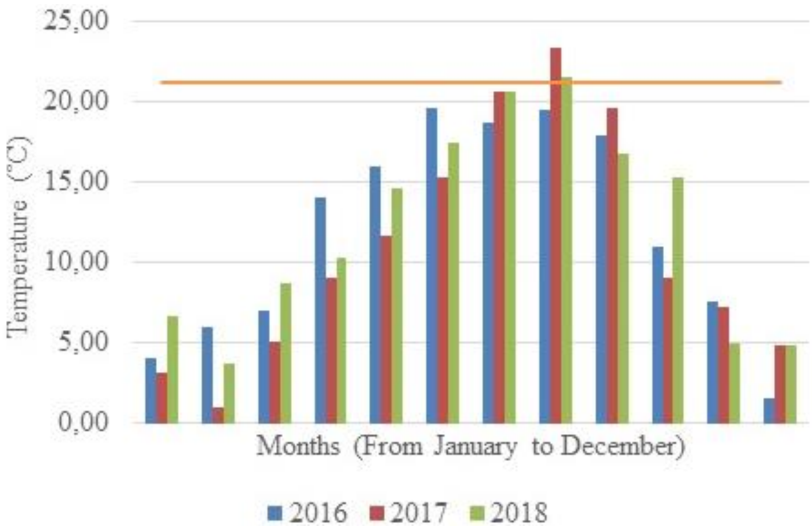

Figure 4. Temperature change graph for Şenkale stream in 2016, 2017 and 2018 by monthly

***Şekil 4.** Şenkale deresi için 2016, 2017 ve 2018 yıllarında aylık sıcaklık değişim grafiği*

3.2. pH
3.2. pH

pH change graph for Şenkale stream in 2016, 2017 and 2018 by monthly is given in Fig. 5. pH value was measured 3 times for each sample, and its average was calculated (TSE, 2012). As can be seen on the pH graph for Şenkale stream, the water quality value (Xr=8.63) was 95% of the limit value. In March 2018 (pH=8.84) and January 2018 (pH=8.67), this limit value was exceeded.

The water quality based on the Hazen method was in the A2 to A3 water quality class according to the RQPDWS and in the interval from class I to class IV according to RARSWQ.

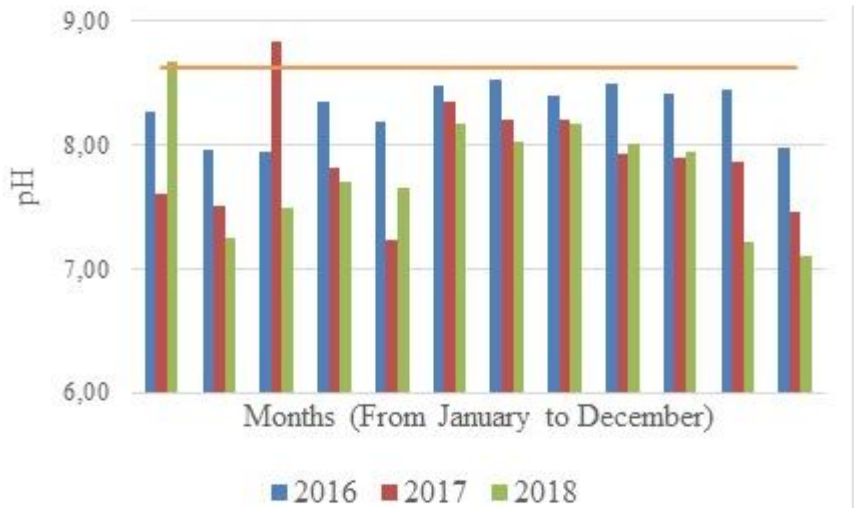

Figure 5. pH change graph for Şenkale stream in 2016, 2017 and 2018 by monthly
***Şekil 5.** Şenkale deresi için 2016, 2017 ve 2018 yıllarında aylık pH değişim grafiği*

3.3. Electrical conductivity (EC)
3.3. Elektiriksel iletkenlik (EC)

EC change graph for Şenkale stream in 2016, 2017 and 2018 by monthly is given in Fig. 6. For each sample, measurements were made three times, with averages taken. The probe was washed with distilled water and rinsed (TSE, 1996). As shown in Fig. 6, the water quality value (Xr=456 µS/cm) was 95% of the limit value. Values were at the limit value in August 2017 (EC=456 µS/cm) and October 2018 (EC=456 µS/cm) and exceeded this value in November 2017 (EC=465 µS/cm).
Water quality value based on the Hazen method was A1 water quality class according to RQPDWS and in the interval from class I to class II according to RARSWQ.

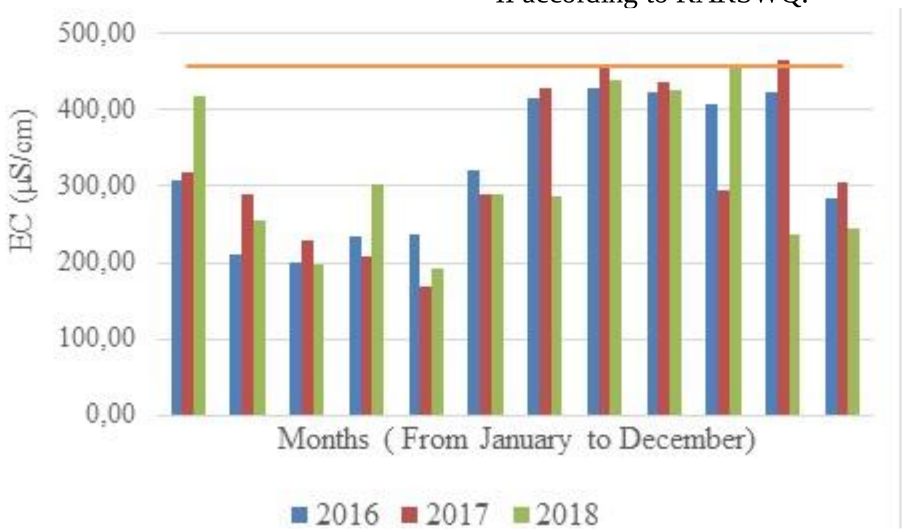

Figure 6. EC change graph for Şenkale stream in 2016, 2017 and 2018 by monthly
***Şekil 6.** Şenkale deresi için 2016, 2017 ve 2018 yıllarında aylık EC değişim grafiği*

3.4. Dissolved oxygen (DO) saturation rate

3.4. Çözünmüş oksijen doygunluk oranı (DO)

DO change graph for Şenkale stream in 2016, 2017 and 2018 by monthly is given in Fig. 7. Before dipping the DO probe into the sample, it was washed with distilled water and rinsed each time. Measurements were made three times for each sample, and the average was calculated (TSE, 2013). As seen in Fig. 7, the water quality value (Xr=103.53%) was at the 95% limit value. This limit value was exceeded in February 2017 (DO=104.10%) and October 2018 (DO=103.80%).

According to the Hazen method, water quality value was A1 class based on RQPDWS and class I water quality according to RARSWQ.

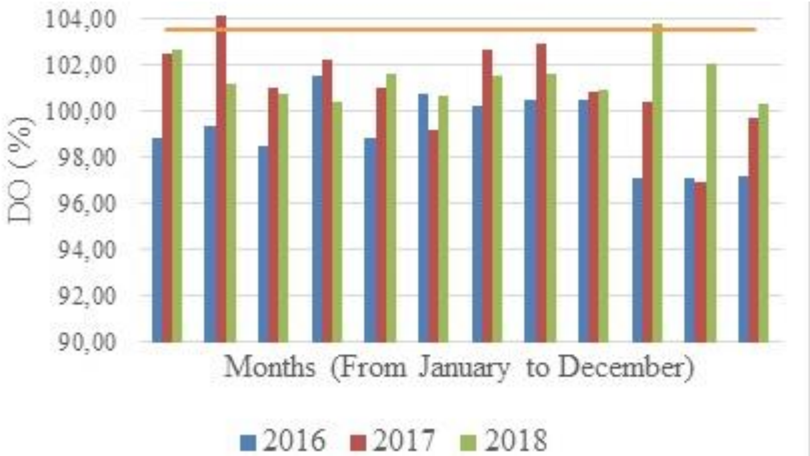

Figure 7. DO change graph for Şenkale stream in 2016, 2017 and 2018 by monthly
Şekil 7. *Şenkale deresi için 2016, 2017 ve 2018 yıllarında aylık DO değişim grafiği*

3.5. Color

3.5. Renk

Color change graph for Şenkale stream in 2016, 2017 and 2018 by monthly is given in Fig. 8 (Eaton et al., 2005). As seen in Fig. 8, the water quality value (Xr=18.25 Pt-Co) was at the 95% limit value. This limit value was exceeded in November 2016 (19.00 Pt-Co) and December 2016 (25.00 Pt-Co).

Based on the Hazen method, the water quality method was in the A1 to A2 water quality class interval according to RQPDWS, and no evaluation with Pt-Co type could be made according to RARSWQ.

Figure 8. Color change graph for Şenkale stream in 2016, 2017 and 2018 by monthly
Şekil 8. *Şenkale deresi için 2016, 2017 ve 2018 yıllarında aylık renk değişim grafiği*

It is observed that the Color (Pt-Co) parameter analysis value for December 2016 in Fig. 8. exceeds the water quality limit value. Due to the fact that it is winter, natural events such as rain and snow have caused the creek to become cloudy. This situation caused the suspended solids or particles to be high by affecting the color parameter.

3.6 Total suspended solid matter (SSM)

3.6. Toplam askıda katı madde (SSM)

SSM change graph for Şenkale stream in 2016, 2017 and 2018 by monthly is given in Fig. 9. Suspended solid matter tests were performed in the laboratory according to the TS EN 872 standard (TSE, 2007). As seen in Fig. 9, Şenkale stream had water quality (Xr=8.00 mg/L) at the 95% limit value. In February 2016 (57.00 mg/L) and October 2018 (9.00 mg/L), this limit value was exceeded.

Based on the Hazen method's water quality limit value was in the A1 water quality class according to RQPDWS, and no classification assessment could be made according to RARSWQ.

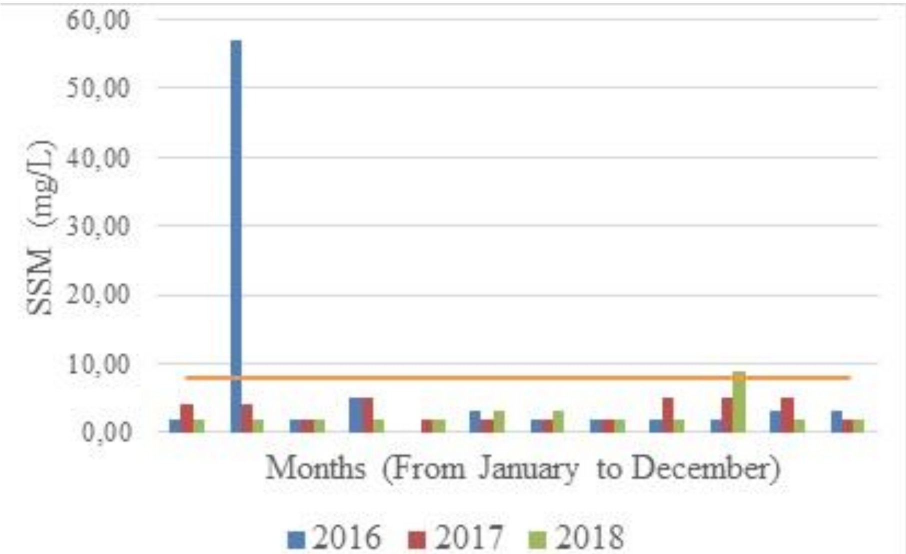

Figure 9. SSM change graph for Şenkale stream in 2016, 2017 and 2018 by monthly
Şekil 9. *Şenkale deresi için 2016, 2017 ve 2018 yıllarında aylık SSM değişim grafiği*

It was observed that the analysis value of the SSM (Suspended Solids) parameter for February 2016 in Fig. 9. exceeded the water quality limit value (Xr). Due to the fact that it is winter, natural events such as rain and snow have caused the creek to become cloudy. This situation caused the suspended solids or particles to be high by affecting the SSM parameter.

3.7. Chemical oxygen demand (COD)

3.7. Kimyasal oksijen ihtiyacı (COD)

COD change graph for Şenkale stream in 2016, 2017 and 2018 by monthly is given in Fig. 10. The lowest chemical oxygen demand limit (detection limit) was 5.0 mg/L. Fig. 10 shows the monthly COD graph for Şenkale stream in 2016, 2017 and 2018. As seen in Fig. 10, the water quality value (Xr=25.00 mg/L) was at the 95% limit value.

The total limit value was observed in May, June, July, August, September, November, and December of 2018 (25.00 mg/L). Based on the Hazen method, the water quality limit value was in the A1 to A2 water quality class interval according to RQPDWS and in class I according to RARSWQ.

Figure 10. COD change graph for Şenkale stream in 2016, 2017 and 2018 by monthly
Şekil 10. *Şenkale deresi için 2016, 2017 ve 2018 yıllarında aylık KOİ değişim grafiği*

It is observed that the analysis value of the COD (Chemical oxygen demand) parameter for the months of May-December 2018 in Fig. 10 does not exceed the water quality value (Xr), but is close.

Chemical oxygen demand is the amount of oxygen used by bacteria to chemically oxidize organic matter during reproduction. A chemical event occurs here. It is caused by the decay of plants and animals in nature and mixing with water.

3.8. Biochemical oxygen demand (BOD_5)
3.8. Biyokimyasal oksijen ihtiyacı (BOD_5)

BOD_5 change graph for Şenkale stream in 2016, 2017 and 2018 by month is given in Fig. 11 (Eaton et al., 2005). As seen in Fig. 11, the water quality value (Xr=4.00 mg/L) was the 95% limit value. In October, November and December 2017 and all months in 2018, the total limit value was observed (4.00 mg/L). Based on the Hazen method, the water quality value was in the A1 to A2 water quality class interval according to RQPDWS and in class I according to RARSWQ.

Figure 11. BOD_5 change graph for Şenkale stream in 2016, 2017 and 2018 by month
Şekil 11. *Şenkale deresi için 2016, 2017 ve 2018 yıllarında aylık BOD_5 değişim grafiği*

It is observed that the BOD parameter for the months of May-December 2018 in Fig. 11. does not exceed the Water quality value (Xr), but is close. BOD, shows almost the same phenomenon as chemical oxygen demand. The difference shows the oxygen they consume biologically during the decomposition of organic materials in the aerobic environment. It is caused by the decay of plants and animals in nature and mixing with water. The data for 2016, 2017 and 2018 obtained from analyses for nitrogen group, total organic carbon (TOC), phosphorus group, anion groups, cation groups, oil and grease, methylene blue active matter (MBAM), cyanide (CN^-), phenols, hydrocarbons, polycyclic aromatic hydrocarbons (PAH), total pesticides and heavy metals (Mn, Fe, Se, Al, Cu, Zn, Co, B, Ni, Cd, As, Cr, Hg, Pb Ba) were assessed according to national water regulations and in the 95% confidence interval using the Hazen method, a statistical method in these regulations. Table 5 gives the water quality values based on the Hazen method for other parameters and the water quality classes according to RQPDWS and RARSWQ.

Table 5. Water quality values based on the Hazen method for other parameters along with the water quality classes according to RQPDWS and RARSWQ (Tarım ve Orman Bakanlığı, 2019).

Tablo 5. *Diğer parametrelerin Hazen Yöntemine Göre Su Kalite Değerleri, RQPDWS and RARSWQ Yöntemlerine Göre Su Kalite Sınıfları (Tarım ve Orman Bakanlığı, 2019)*.

Parametres	Water Quality Values Accordıng To Hazen Method	Water Quality Class According to RQPDWS	Water Quality Class According to RARSWQ
TKN(Total Kjeldahl Nitrogen)(mg/L)	1.37	A class assessment cannot be made.	Between I.-II. classes
NO^{-3}(mg/L)	2.261	A1	I.class
F^- (μg/L)	935	A1	I.class
SO_4^{-2} (mg/L)	65.73	A1	A class assessment cannot be made.
Cl^- (mg/L)	9.54	A1	A class assessment cannot be made.
NH_3-N (mg/L)	1.16	A class assessment cannot be made.	III. class
TOC(mg/L)	5.71	A3	A class assessment cannot be made.
o-$PO4^{-3}$ (mg/L)	0.08	A1	Between I.-II. classes
Oil and Grease (mg/L)	0.26	A class assessment cannot be made.	I.-II. classes
MBAM (mg/L)	0.20	A class assessment cannot be made.	A class assessment cannot be made
Phenols (mg/L)	0.020	A3	A class assessment cannot be made
CN^- (mg/L)	0.010	A1	Below the Max. Environmental Quality System Value
Hydrocarbons (mg/L)	1.15	A3	A class assessment cannot be made
PAH (μg/L)	0.1229	A2	Below the Max. Environmental Quality System Value
Pesticide (μg/L)	0.50	A1	Below the Maximum Environmental Quality System Value
Al (μg/L)	277.96	A1	Above the Max. Environmental Quality System Value
Fe (μg/L)	223.81	A2	Above the Max. Environmental Quality System Value
Mn (μg/L)	43.39	A1	I.class
Se (μg/L)	3.88	A1	I.class
Cu (μg/L)	65.27	A1	Above the Max. Environmental Quality System Value
Zn (μg/L)	211.93	A1	Below the Max. Environmental Quality System Value
Bor (μg/L)	330.77	A1	Below the Max. Environmental Quality System Value
Co (μg/L)	1.00	A1	Below the Max. Environmental Quality System Value
Ni (μg/L)	11.18	A1	Below the Max. Environmental Quality System Valu
As (μg/L)	1.68	A1	Below the Max. Environmental Quality System Value
Cd (μg/L)	1.00	A1	Below the Max. Environmental Quality System Value
Cr (μg/L)	1.09	A1	Between the Max. Environmental Quality System Value
Pb (μg/L)	5.84	A1	Below the Max. Environmental Quality System Value
Hg (μg/L)	<0.05	A1	Below the Max. Environmental Quality System Value
Ba (μg/L)	55.24	A1	Below the Max. Environmental Quality System Value

4. **Discussion and conclusion**

4. Tartışma ve sonuç

The main conclusions and recommendations from this study are given below;

- International methods were used to determine the water quality parameters of Şenkale stream poured the Bahçecik dam.
- Parameters having instantaneous variabilities such as temperature, pH, EC, and DO should be analyzed during sampling. As a result, to assess these monthly samples more accurately, it is recommended to construct daily online measurement stations.
- According to RQPDWS; TKN, NH_3-N, Oil-grease and MBAM are in the a class assesment cannot be made. TOC, Phenols and Hydrocarbons are in the A3 quality class. PAH and Fe are in the A2 quality class. NO^{-3}, F^-, SO_4^{-2}, Cl^-, o-$PO4^{-3}$, CN^-, Pesticide, Al, Mn, Se, Cu, Zn, B, Co, Ni, As, Cd, Cr, Pb, Hg and Ba are in the A1 quality class. According to RARSWQ; TKN and o-PO_4^{-3} are in between I-II class quality standards. NO^{-3}, F^-, Mn and Se are in I.class. NH_3-N is in the III. class. SO_4^{-2},

Cl, TOC, MBAM, Phenols and Hydrocarbons are in a class assessment cannot be made.

- CN^-, PAH, Pesticide, Zn, Bor, Co, Ni, As, Cd, Pb, Hg and Ba are in the below the maximum environmental quality system value. Al, Fe and Cu are in the above the maximum environmental quality system value.
- To better determine water quality parameters, it is necessary to consider the fluvial system's whole. Considering thousands of micropollutants under current conditions is quite essential.
- It is necessary to filter water before reaching the treatment units to remove physical pollutants.
- Aeration processes release organic volatiles.
- It is required to precipitate dissolved heavy metals such as Fe and Mn to convert them to insoluble forms. The ozone process is used to degrade organic matter, causing KOI. More toxic heavy metals, including arsenic and mercury, require chemical treatment techniques and membrane filtration techniques.
- The use of more comprehensive advanced treatment methods than simple treatment methods are significant to obtain higher quality effluents.
- Additionally, assessment for agricultural chemicals, in other words, pesticides, hydrocarbons, phenols and polycyclic aromatic hydrocarbons, requires a separate expert staff, which needs teamwork.
- Finally, it is necessary to inform the public about not using agricultural chemicals that affect fluvial systems

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Author contribution
Yazar katkısı

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Declaration of ethical code
Etik beyanı

Authors of this article declare that materials and methods used in this study do not require ethical committee approval and/or legal-specific permission.

Conflict of interest
Çıkar çatışması beyanı

The authors declare that there is no conflict of interest.

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