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RESEARCH ARTICLE

The Effects of Water Quality Parameters on Summer Dynamics of Phytoplankton and Zooplankton in the Tributaries of Murat River (Hınıs, Erzurum)

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ABSTRACT

This study aimed to investigate the spatial variations in phytoplankton and zooplankton composition in relation to selected water quality parameters across five tributaries of the Murat River. The research encompassed physical and chemical parameters, chlorophyll-*a* levels, zooplankton and phytoplankton composition and biodiversity indices within the tributaries. A total of seven zooplankton species were identified, comprising 40% Copepoda, 37.14% Cladocera and 22.86% Rotifera, with *Cyclops vicinis* emerging as the dominant species. Additionally, 34 species from the Bacillariophyta, Chlorophyta and Cyanobacteria groups were recorded. The Shannon-Wiener and Margalef Biodiversity Indices revealed that zooplankton diversity peaked at the 5th station, while phytoplankton diversity was highest at the 3rd station. The average concentrations of total phosphorus (TP) and ammonia nitrogen (NH_3-N) were measured as 5.93 mg L^{-1} and 3.02 mg L^{-1}, respectively. Chlorophyll-*a* values ranged from 0.001 mg L^{-1} at the 1st station to 0.011 mg L^{-1} at the 5th station. According to the Trophic Diatom Index (TDI), the water quality was categorized as poor, while other indices indicated medium water quality. In conclusion, the findings highlight that the tributaries of the Murat River are under significant threat from anthropogenic pollution. Urgent mitigation measures are recommended to safeguard these water resources.

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1. Introduction

Streams are dynamic aquatic ecosystems containing suspended organic and inorganic matter, dissolved nutrients and gases. These systems are highly vulnerable to anthropogenic pressures such as climate change, population growth and pollution. Therefore, understanding the current ecological status of stream systems is essential for their protection and sustainable management.

Environmental pollution, with its multifaceted impacts, has become a global issue. The European Water Framework Directive, implemented by the European Union in 2000, marked a significant step in the management of inland waters. This directive categorizes surface waters into four main types:

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lakes, rivers, transitional waters and coastal waters. It also identifies biological quality indicators—phytoplankton, phytobenthos, macrophytes, macroinvertebrates and fish—to assess the ecological status of these water bodies (Anonymous, 2003a; T.C. Başbakanlık Devlet Planlama Teşkilatı, 1998). In Türkiye, research on monitoring and evaluating water bodies in accordance with the necessities of Water Framework Directive has gained importance.

Diatom indices have been developed and widely applied to determine the trophic status of streams in various countries (Kıvrak et al., 2012). Examples of these indices include the Descy and Coste Diatom Index (Descy & Coste, 1991), Generic Diatom Index (Coste & Ayphassorho, 1991), Leclercq and Maquet Index (Leclercq & Maquet, 1987), Steinberg and Schiefele Index (Steinberg & Schiefele, 1988) and the Trophic Diatom Index (Kelly & Whitton, 1995; Kelly, 1998).

Plankton, which migrate passively within aquatic environments, play a critical role in sustaining life. While they are abundant in marine systems, they also thrive in inland waters. The dynamics of these organisms in streams differ from those in lakes or reservoirs, as they are influenced by constantly changing physical conditions, such as temperature, pH, dissolved oxygen and flow rate. Nutrient inputs from agricultural, industrial and urban activities further impact these dynamics (Tanyolaç, 2009). Assessing the distribution of planktonic organisms in streams is therefore crucial for ecological evaluations. Furthermore, phytoplankton, macrophytes, benthic invertebrates and fish have been recognized as key biological indicators (Bakır, 2015).

This study was conducted in the Başköy and Kocasu streams, tributaries of the Murat River located in the Hınıs district of Erzurum. It aimed to analyze zooplankton and phytoplankton populations, water quality parameters, chlorophyll-*a* (chl-*a*) and biodiversity indices in the region. The objective was to determine the index values of plankton dynamics and explore the relationship between primary producers and nutrient levels. Given the lack of prior studies on these streams, this research fills a critical knowledge gap and provides a foundation for future investigations. The findings are expected to contribute significantly to understanding the ecological dynamics of tributaries with substantial water potential, such as the Murat River.

2. Materials and Methods

2.1. Study Area

The Murat River, with a length of 722 km, is one of the longest rivers in the region. Originating in the Muratbaşı Mountains near Lake Van, it flows southward, irrigating the Ağrı region and collecting waters from tributaries such as the Hınıs streams (Kocasu and Başköy). It eventually merges with the Karasu River to form the Euphrates River (Kirici et al., 2016; Koyun, 2011).

The study was conducted in the Hınıs region, which contains over 20 large and small streams. These streams converge and flow into the Murat River approximately 30 km downstream. Sampling was performed in five selected streams at altitudes ranging from 1560 to 1650 meters. Phytoplankton, zooplankton and water samples were collected from these locations in June 2024. Details of the sampling stations, including coordinates and hydro-morphological characteristics, are provided in Table 1, and the map of the stations is shown in Figure 1.

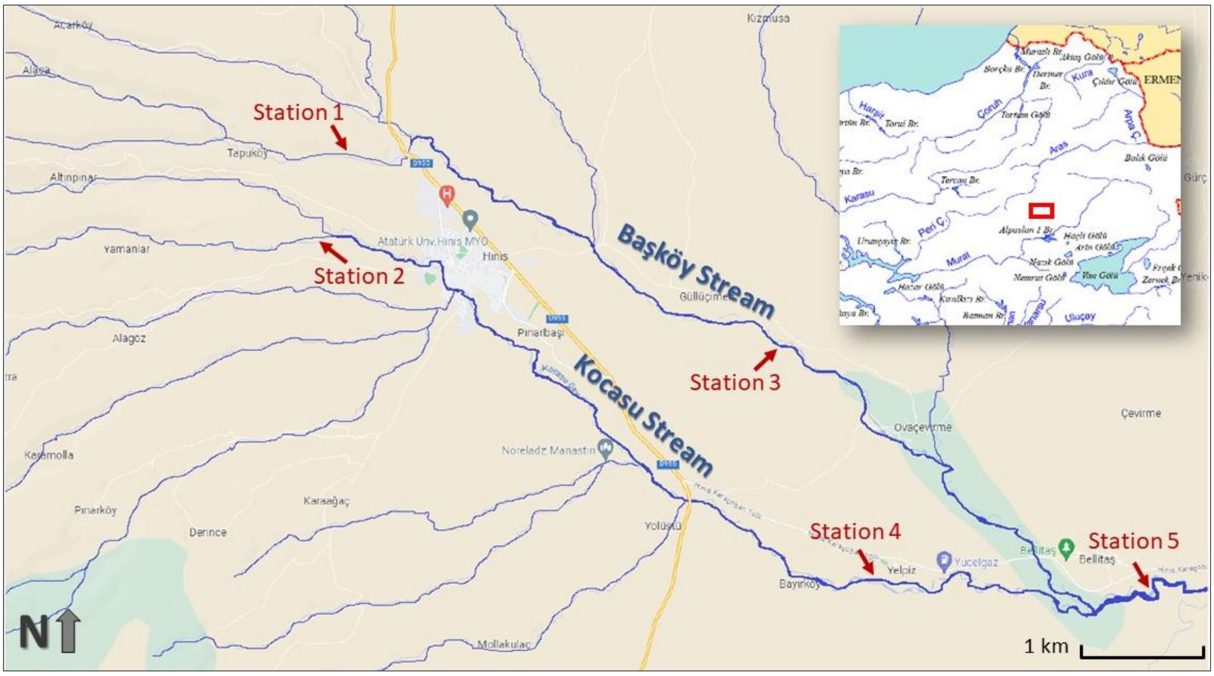

Figure 1. Map of study area.

Table 1. Hydro-morphological characteristics of the tributaries of the Murat River.

Stations	Name of Streams	Altitude	Coordinate	Flow rate (m/s)	Flow (m^3/s)	Depth (m)
1	Alaca Creek	1650m	39°22'34"N, 41°41'16"E	0.9	0.1	0.78
2	Şeyhnadir Creek	1750m	39º21'39"N, 41º39'20"E	1.33	0.09	0.38
3	Başköy Creek	1615m	39°21'40"N 41°43'44"E	0.83	0.28	0.38
4	Kocasu Creek	1595m	39°19'07"N 41°45'03"E	1.5	0.27	0.4
5	The location after intersection of Başköy and Kocasu Creeks	1560m	39°18'21"N 41°51'13"E	1.21	1.06	0.5

2.2. Sampling and Analysis

2.2.1. Physicochemical parameters

Water temperature, pH, dissolved oxygen and conductivity were measured *in situ* using a YSI multiparameter probe. Turbidity measurements were recorded with an Extech turbidimeter. Water samples for nitrite nitrogen (NO_2^--N), nitrate nitrogen (NO_3^--N), ammonium nitrogen (NH_3-N), orthophosphate (PO_4^{3-}) and total phosphorus (TP) were transported to the laboratory and analyzed spectrophotometrically following APHA protocols (APHA, 2001). Chl-*a* was measured using spectrophotometry after filtering samples through 45 µm Whatman filter papers on the day of sampling (Strickland & Parsons, 1972). Total hardness was determined titrimetrically as per APHA (1995) guidelines.

2.2.2. Zooplankton sampling and identification

Zooplankton samples were collected by filtering water through standard plankton nets with a mesh size of 60 µm. The samples were preserved in 4% formalin for further analysis. Zooplankton species were identified and quantified under a light microscope using taxonomic keys, including Edmondson (1959), Scourfield and Harding (1969), Kolisko (1974) Stemberger (1979) and Segers (1995) for Rotifera; Kiefer and Fryer (1978), Koste (1978a,b) and Negrea (1983) for Cladocera; and Borutskii (1964), Flössner (1972), Einsle (1996) and Dussart and Defaye (2001) for Copepoda.

2.2.3. Phytoplankton sampling and identification

Phytoplankton samples were collected using plankton nets with a 10 µm mesh size. Species composition was identified using a Zeiss binocular microscope (magnifications: 100x, 200x and 400x) following taxonomic literature (Cox, 1991, 1996; John et al., 2002). Final taxonomic names were verified using the AlgaeBase database (https://www.algaebase.org). Quantitative samples were collected with a Ruttner water sampler, and phytoplankton counts were conducted in Hydrobios plankton counting chambers after preserving samples with Lugol's solution (Anonymous, 2003b; Utermöhl, 1958).

2.3. Biodiversity Indices

2.3.1. Shannon-Wiener Diversity Index (H')

The Shannon-Wiener Index, derived by Shannon in 1948, is calculated using the formula:

$$H' = -\sum_{i=1}^{s} pi \log_e pi \quad (1)$$

Where, s: Total number of species; pi: Proportion of individuals belonging to species (ni) to total number of individuals (n).

2.3.2. Simpson Diversity Index (D)

The Simpson Diversity Index is calculated as (Hill, 1973; James & Aderaje, 2010; Krebs, 1998; Kwak & Peterson, 2007):

$$1 - D = \frac{\sum ni(ni-1)}{N(N-1)} \quad (2)$$

Where, ni: Number of individuals belonging to species; N: Total number of individuals.

2.3.3. Margalef Diversity Index (Dmg)

The Margalef Index is given by (James & Aderaje, 2010):

$$D = \frac{S-1}{\log N} \quad (3)$$

Where, S: Number of species; N: Total number of individuals.

2.4. Data Evaluation

Diatom indices were calculated using OMNIDIA 5.2 software (Lecointe et al., 1993). The results were interpreted according to the scoring criteria by Lenoir and Coste (1996). Statistical differences among environmental parameters at different sites were assessed using one-way ANOVA in IBM SPSS 20.0, followed by Duncan's test to determine significance levels. Cluster observation analysis was performed using MINITAB software. Canonical correspondence analysis (CCA) was conducted using PAST 4.03 to analyze the relationship between environmental factors and phytoplankton biomass.

3. Results

3.1. Water Quality Parameters

Significant variations in water temperature, dissolved oxygen, pH, electrical conductivity, turbidity, hardness, NH_3-N, NO_3-N, NO_2-N, TP, PO_4-P and chl-*a* were observed across the sampling stations ($p < 0.05$). The highest water temperature (21.7 °C) was recorded at 5th station, the lowest-altitude site, while 2nd station, the highest-altitude site, had the lowest temperature (18.0 °C). Dissolved oxygen values ranged from 9.51 mg L^{-1} at 1st station to 5.78 mg L^{-1} at 4th station. The highest pH was recorded at 1st station (8.04) and the lowest at 4th station (7.91). Electrical conductivity peaked at 5th station (0.35 mS/cm) and was lowest at 2nd station (0.10 mS/cm). Turbidity values varied significantly, with 1st station exhibiting the highest value (38.51 NTU) and 5th station the lowest (10.45 NTU).

Orthophosphate phosphorus (PO_4-P) values ranged from 0.01 mg L^{-1} to 0.02 mg L^{-1} across stations. Ammonia nitrogen (NH_3-N) had an average concentration of 2.96 mg L^{-1} across all stations, with the highest concentration at 5th station (7.73 mg L^{-1}). Nitrate nitrogen (NO_3-N) was lowest at 1st, 2nd and 3rd stations (0.04 mg L^{-1}) and slightly higher at 4th and 5th stations (0.05 mg L^{-1}). Nitrite nitrogen (NO_2-N) concentrations varied from 0.47 µg L^{-1} at 2nd station to 2.33 µg L^{-1} at 4th station (Table 2).

The results obtained in this study were evaluated in comparison with the limit values specified in the Surface Water Quality Regulation (SWQR) (YSKY, 2015). Based on these evaluations, the quality classes of the stations were determined according to specific parameters. All stations were classified as Class I waters based on water temperature, electrical conductivity, PO_4-P and NO_3-N concentrations according to SWQR. Dissolved oxygen levels indicated that the 1st and 5th stations were Class I waters, while the 2nd, 3rd and 4th stations were classified as Class II waters (Table 3).

According to the SWQR, the 1st station (1.10 mg L^{-1}) and 2nd station (1.24 mg L^{-1}) were classified as Class II, the 3rd station (1.61 mg L^{-1}) as Class III, and the 4th station (3.13 mg L^{-1}) and 5th station (7.72 mg L^{-1}) as Class IV waters based on ammonia nitrogen concentrations. These classifications were made following the Quality Criteria of Surface Water Quality Management Regulation for Intra-Continental Surface Water Resources (YSKY, 2015) (Table 3).

Table 2. Changes in water quality parameters and chl-*a* values across stations.

Parameter	Station 1	Station 2	Station 3	Station 4	Station 5
Water temperature (°C)	20.04±0.0^{b*}	19.13±0.33^{c}	18.00±0.0^{d}	19.00±0.06^{c}	21.7±0.21^{a}
Dissolved Oxygen (mgL $^{-1}$)	9.51±1.89^{a}	7.07±0.77^{a}	6.94±0.40^{a}	5.78±0.33^{a}	9.38±0.18^{a}
pH	8.14±0.01^{a}	8.04±0.03^{a}	8.03±0.26^{a}	7.90±0.02^{a}	8.11±0.01^{a}
EC (mS/cm)	0.11±0.00^{c}	0.24±0.03^{b}	0.10±0.00^{c}	0.22±0.00^{b}	0.35±0.02^{a}
Turbidity (ntu)	38.51±4.85^{a}	34.76±2.67^{a}	17.38±0.20^{b}	17.51±0.97^{b}	11.13±1.07^{b}
NH_3-N (mg L $^{-1}$)	1.10±0.18^{a}	1.61±0.51^{a}	1.24±0.05^{a}	3.13±0.69^{a}	7.73±4.31^{a}
NO_3-N (mg L $^{-1}$)	0.04±0.00^{a}	0.04±0.00^{a}	0.04±0.00^{a}	0.05±0.01^{a}	0.05±0.01^{a}
NO_2-N (µg L $^{-1}$)	0.94±0.04^{b}	1.73±0.33^{a}	0.47±0.09^{b}	2.33±0.07^{a}	2.23±0.01^{a}
TP (mg L $^{-1}$)	1.58±0.08^{a}	3.20±0.34^{a}	1.84±1.07^{a}	4.12±2.72^{a}	3.34±0.03^{a}
PO_4-P (mg L $^{-1}$)	0.02±0.00^{a}	0.02±0.00^{ab}	0.01±0.00^{c}	0.02±0.00^{a}	0.01±0.00^{bc}
Total Hardness (mg L $^{-1}$)	31.35±13.65^{a}	75.05±1.20^{a}	17.95±2.47^{a}	81.65±3.46^{a}	291±168^{a}
Chl-*a* (mg L $^{-1}$)	0.001±0.00^{d}	0.002±0.00^{c}	0.002±0.00^{d}	0.009±0.00^{b}	0.011±0.00^{a}

***** a, b, c, d indicate the difference in water quality parameters between stations. The difference between groups shown with different lowercase letters in the same line is statistically significant (p<0.05).

Table 3. Assessment of tributaries of Murat River based on selected water quality parameters (blue: Class I water, green: Class II water, yellow: Class III water and red: Class IV water).

Parameter \ Stations	1	2	3	4	5	SWQR (YSKY, 2015)
Water temperature (ºC)	20.04	19.13	18.00	19.00	21.7	19.57
Dissolved oxygen (mg L^{-1})	9.51	7.07	6.94	5.78	9.38	7.74
pH	8.14	8.04	8.03	7.90	8.11	8.04
EC (mS/cm)	0.11	0.24	0.10	0.22	0.35	0.20
PO_4-P (mg L^{-1})	0.02	0.02	0.01	0.02	0.01	0.02
NH_3-N (mg L^{-1})	1.10	1.61	1.24	3.13	7.73	2.96
NO_3-N (mg L^{-1})	0.04	0.04	0.04	0.05	0.05	0.04
NO_2-N (mg L^{-1})	0.94	1.73	0.47	2.33	2.23	1.54

Chl-*a* concentrations varied between 0.001 mg L^{-1} to 0.011 mg L^{-1} across stations, with the highest value at 5th station (Figure 2), and the differences between stations were found to be statically significant ($p<0.05$, Table 2).

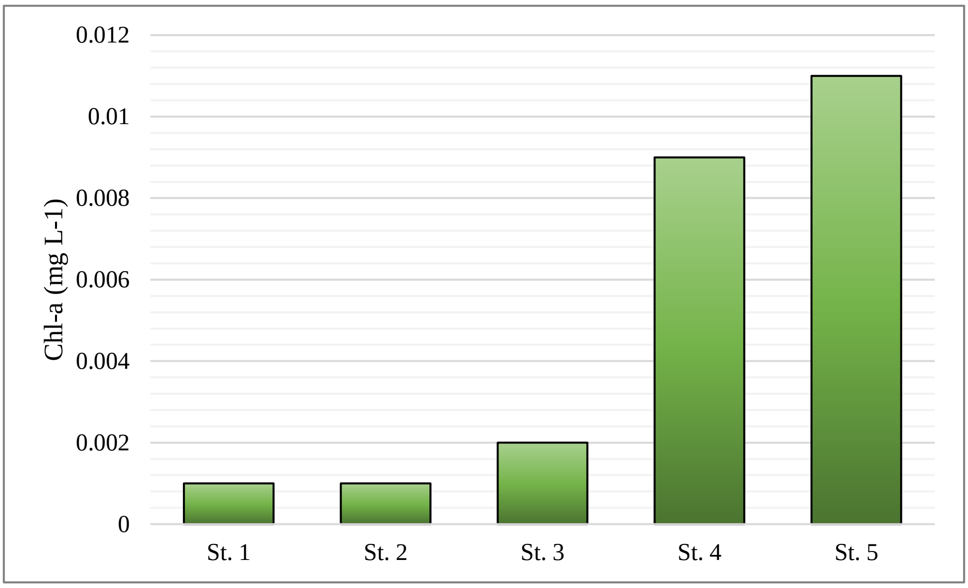

Figure 2. Changes in chl-*a* concentration across the stations (Mean±SD, n=4).

3.2. Phytoplankton and Zooplankton Composition

A total of 34 phytoplankton species from Bacillariophyta, Chlorophyta and Cyanobacteria groups and 7 zooplankton species from Cladocera, Copepoda and Rotifera groups were identified. *Encyonema latens*, *Navicula lanceolata* and *Cyclops vicinus* were present at all stations (Table 4).

Table 4. Phytoplankton and zooplankton species identified across stations.

Species	Stations				
	1	2	3	4	5
Phytoplankton					
Classis: Bacillariophyta					
***Caloneis* sp.**		+			
***Cocconeis placentula* Ehrenberg**	+	+	+		+
***Craticula accomoda* (Hustedt) D.G.Mann**					+
***Diatoma* vulgaris Bory**					+
***Encyonema latens* (Krasske) D.G.Mann**	+	+	+	+	+
***Epithemia* sp.**				+	
***Fragilaria capucina* Desmazières**	+	+			
***Fragilaria* sp.**				+	
***Fallacia insociabilis* (Krasske) D.G.Mann**	+		+	+	+
***Geissleria schoenfeldii* (Hustedt) Lange-Bertalot & Metzeltin**			+		
***Gomphonema* sp.**	+	+	+		+
***Gomphonema truncatum* Ehrenberg**					+
***Hannaea arcus* (Ehrenberg) R.M.Patrick**	+		+		
***Melosira varians* C.Agardh**				+	
***Navicula cryptotenella* Lange-Bertalot**	+		+		
***Navicula lanceolata* Ehrenberg**	+	+	+	+	+
***Navicula reinhardtii* (Grunow) Grunow**	+	+	+		
***Nitzschia capitellata* Hustedt**			+	+	+

Table 4. (continued).

Species	**Stations**				
	1	**2**	**3**	**4**	**5**
Phytoplankton					
Classis: Bacillariophyta					
***Nitzschia* sp.**	+	+	+	+	
***Pinnularia* sp.**				+	
***Placoneis* sp.**		+			
***Rhizosolenia* sp.**				+	+
***Rhopalodia* sp.**	+	+	+	+	
***Staurosira neoproducta* (Lange-Bertalot) Chudaev & Gololobova**			+		
***Stephanocyclus meneghinianus* (Kützing) Kulikovskiy, Genkal & Kociolek**	+	+	+	+	
***Surirella brebissonii* Krammer & Lange-Bertalot**			+		
***Surirella librile* (Ehrenberg) Ehrenberg**				+	
Classis: Chlorophyta					
***Comasiella arcuata* (Lemmermann) E.Hegewald, M.Wolf, Al.Keller, Friedl & Krienitz**		+			
***Scenedesmus* sp.**	+		+		
***Tetraedron minimum* (A.Braun) Hansgirg**		+			
***Tetradesmus bernardii* (G.M.Smith) M.J.Wynne**				+	
***Tetradesmus dimorphus* (Turpin) M.J.Wynne**			+	+	
***Tetradesmus obliquus* (Turpin) M.J.Wynne**			+		
Classis: Cyanobacteria					
***Oscillatoria* sp.**	+	+	+	+	
Zooplankton					
Group: Cladocera					
***Bosmina longirostris* (O.F. Müller, 1785)**	+		+		+
***Daphnia cucullata* (Sars, 1862)**		+		+	+
Group: Copepoda					
***Cyclops vicinus* (Sars, 1863)**	+	+	+	+	+
Group: Rotifera					
***Keratella quadrata* (O. F. Müller, 1785)**					+
***Polyarthra dolichoptera* (Idelson, 1925)**					+
***Philodina roseola* (Ehrenberg, 1832)**			+	+	+
***Brachionus angularis* (Gosse, 1851)**					+

3.2.1. Abundance and diversity

The average phytoplankton density was 130,493.7 cells/m³, while the zooplankton count averaged 70 individuals/m³. Phytoplankton abundance was highest at 3rd station, whereas zooplankton density peaked at 5th station (Figure 3).

Bacillariophyta was found to be the highest rate among phytoplankton groups, while the Copepoda was determinate to be approximately 50% within the zooplankton group (Figure 4).

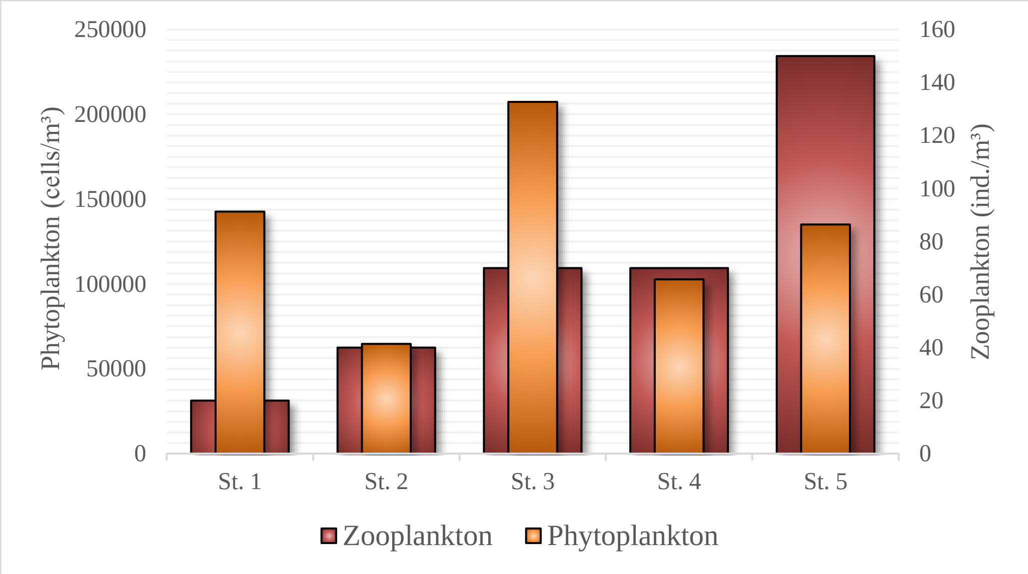

Figure 3. Phytoplankton and zooplankton abundance across stations.

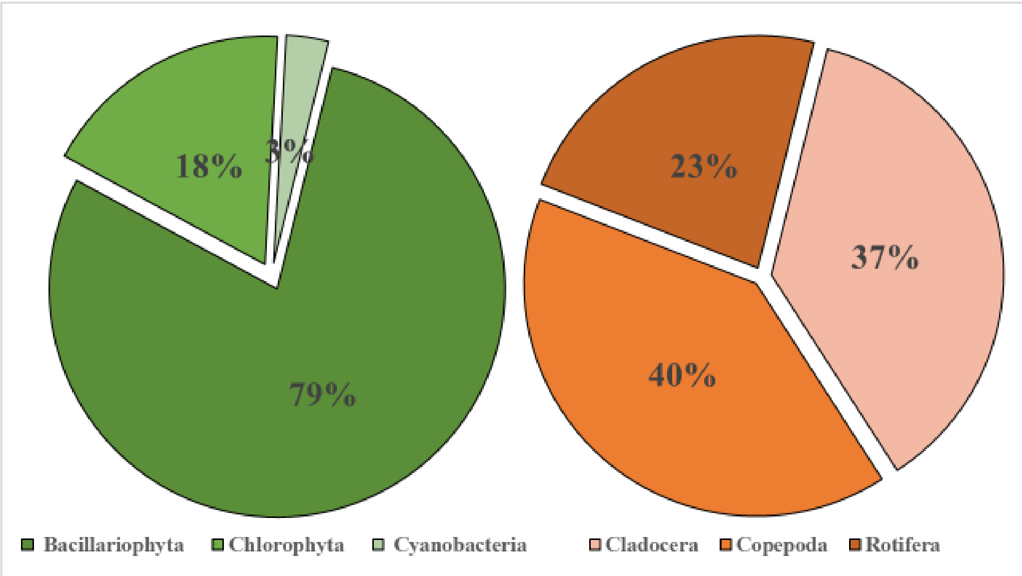

Figure 4. Distribution of phytoplankton and zooplankton groups in the study area.

3.2.2. Biodiversity indices

Moderate phytoplankton biodiversity was observed at all stations based on the Shannon-Wiener Index. However, Simpson and Margalef indices indicated low phytoplankton and zooplankton biodiversity, except at 5th station, which exhibited the highest zooplankton diversity (Figure 5).

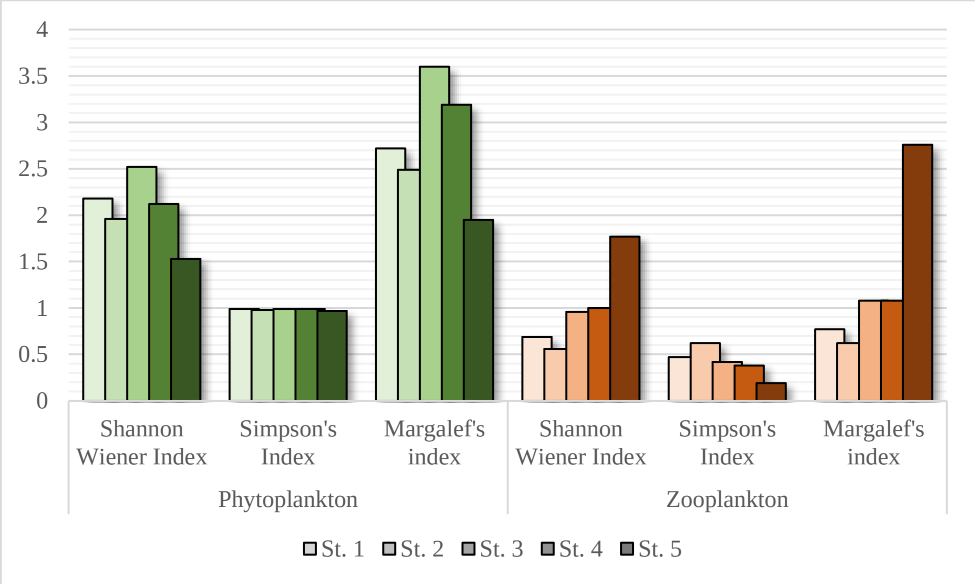

Figure 5. Biodiversity indices of phytoplankton and zooplankton groups in the study area (From light to dark colour for 1st to 5th station).

3.3. Canonical Correspondence Analysis (CCA)

CCA analysis revealed strong correlations between nutrient levels (TP, NH_3-N, NO_2-N, NO_3-N) and water temperature with diatom indices such as EPID, Rott SI and TDI. However, no significant relationships were observed for IBD, SHE and IPS indices (Figure 6).

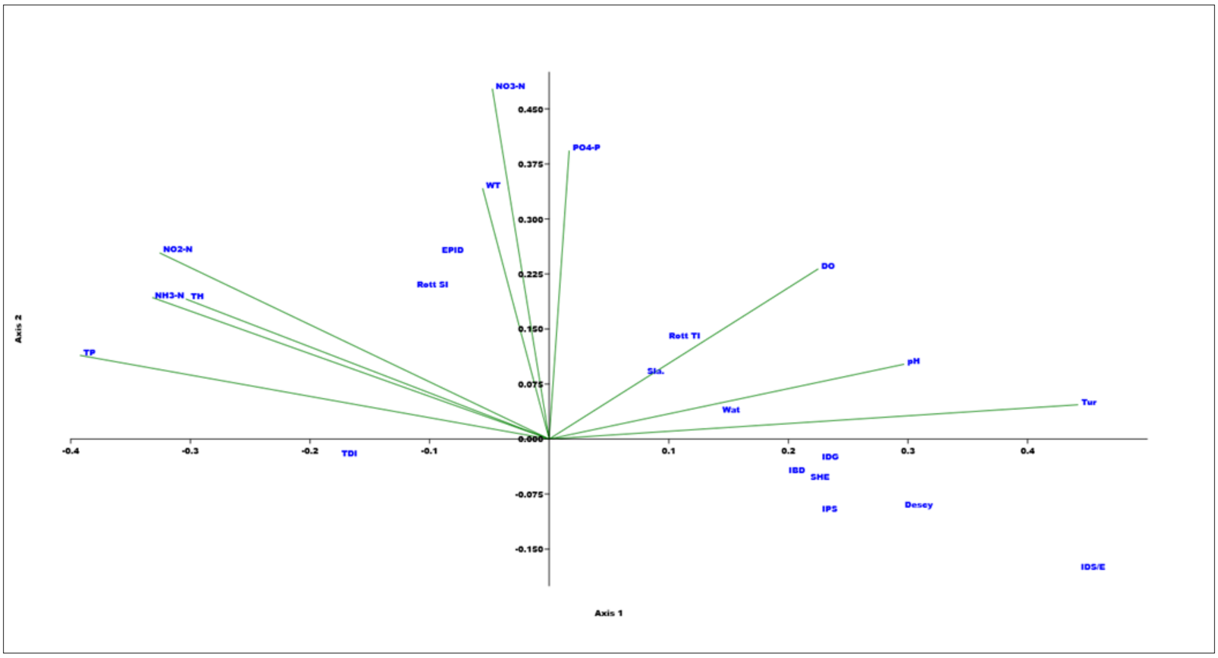

Figure 6. Canonical correspondence analysis of diatom indices and water quality parameters (WT: water temperature, DO: dissolved oxygen, NH_3-N: ammonia nitrogen, NO_2-N: nitrite-nitrogen, NO_3-N: nitrate-nitrogen, PO_4-P: orthophosphate phosphorus, TP: total phosphorus, TH: total hardness, Tur: turbidity).

4. Discussion

According to the SWQR, the streams and rivers examined in this study were categorized as clean river systems based on water quality parameters. However, ammonia nitrogen concentrations indicated that Başköy Stream, Kocasu Stream and the intersection of Başköy and Kocasu Streams were within the polluted water category. Koyun et al. (2020) was determinate that the Murat River within the Bingöl province, as "fourth class water quality" depend on pH and nitrogen derivative concentrations, and as "first class water quality" depend on other parameters according to the Surface Water Quality Management Regulation. These studies show that pollution related to nitrogen, because of anthropogenic impact, especially in the urban area like as in this result of research (Kerkmann et al., 2012; Koyun et al., 2020).

Physical and chemical parameters such as water temperature, dissolved oxygen and pH are important factors that affect lower food web relationships. These parameters, which have a significant impact on the life cycle of zooplankton and phytoplankton, were found to be at values suitable for the reproduction of these organisms for temperature (Mikschi, 1989), sufficient alkaline amount for pH (Bērziņš & Pejler, 1987) and tolerable levels for dissolved oxygen (Moss, 2007) in the study area.

The average results of pH, water temperature, dissolved oxygen, EC and total hardness was similar with a study conducted downstream of Murat River (Koyun et al., 2020). However, when the results are compared with studies conducted in the Euphrates River Basin, it is observed that dissolved oxygen concentrations decrease in relation to the hydro-morphological characteristics of the basin (Bulut & Saler, 2019).

Variations in conductivity can affect the ability of aquatic organisms to regulate their internal salt balance, potentially leading to stress or even death. Pulatsü et al. (2014) indicated that electrical conductivity values between 1 and 1000 μS/cm are acceptable for river systems. The findings of this study revealed that the electrical conductivity values for the tributaries of the Murat River fall within this range.

In river ecosystems, chl-*a* concentrations are associated with nutrient inputs. Elevated and sustained nutrient inputs, particularly beyond the eutrophication threshold of 0.2 mg L^{-1} for total nitrogen (TN) and 0.02 mg L^{-1} for total phosphorus (TP), can result in chl-*a* concentrations of up to 2.50 mg L^{-1} (Liao et al., 2021). In this context, the study revealed that nitrogen and phosphorus loads were lower at stations with higher altitudes and minimal pollutant influences. Conversely, stations in regions with intensive livestock activities exhibited higher nutrient loads.

In a study conducted on Murat River in Palu district, NH_4 values varied between 0.4 - 0.7 mg L^{-1} (Topal & Topal, 2016), which differs from this study. The high ammonia nitrogen concentrations in Kocasu and Başköy Streams can be attributed to the low regeneration ability due to the morphological characteristics of this stream.

Unlike in this study, a previous investigation on the Murat River found rotifers to be the dominant group (Bulut & Saler, 2014). The higher presence of copepods compared to rotifers in this study may suggest that the sampling area has cleaner waters than the downstream section of the Murat River. It is known that copepods are more abundant in oligotrophic waters, whereas rotifers thrive in eutrophic conditions (Herzig, 1987). The low concentration of water quality parameters (except ammonia nitrogen) observed in this study supports this finding. All zooplankton species identified during the research on Kocasu and Başköy Streams are included in the published checklists of zooplankton (Ustaoğlu, 2004) and rotifers (Ustaoğlu et al., 2012).

This study identified Bacillariophyta group algae, predominantly pennate diatoms such as *U. ulna* and *Gomphonema* species, which are considered moderately tolerant or pollution-tolerant taxa (Kelly et al., 2008; Salinas-Camarillo et al., 2021; Van Dam et al., 1994). Additionally, the presence of cyanobacterial species signified pollution within the streams and creeks. Although the Shannon-Wiener biodiversity index indicated high phytoplankton biodiversity, the Simpson Diversity Index and Margalef Diversity Index highlighted low biodiversity for both phytoplankton and zooplankton. The scarcity of identified plankton species and/or low counts, along with the absence of previous studies on the plankton community in this area, may contribute to the variable diversity observed. Therefore, it is recommended to expand the study and examine a wider area.

The study further evaluated the water quality of the tributaries using diatom indices. The results showed poor water quality based on the TDI and moderate quality according to the Steinberg and Schiefele Index (SHE), Sládeček Intermediate Index (SLA) and EPI-D index. Significant correlations were observed between EPI-D, TDI and ROTT indices with TP, NH_3-N and NO_2-N concentrations ($p < 0.01$). These findings align with Ongun Sevindik et al. (2023), who reported strong correlations of EPI-D, TDI, IDP and ROTT indices with NO_3-N and TN values, concluding that the TDI index provides a consistent measure of ecological status. Studies based on biological data have just begun in this region, and there is a need for this kind of studies to be examined in more detail.

5. Conclusion

This study investigated the ecological status of streams and creeks within the Murat River system, considering both water quality parameters and diatom index values. The findings indicate that these water sources are subjected to medium pollution levels. The presence of low biodiversity, elevated ammonia nitrogen concentrations, and pollution-tolerant taxa such as *Oscillatoria sp.* and pennate diatoms underscores the influence of anthropogenic pollutants on these aquatic systems. The results highlight an urgent need for measures to mitigate pollution and safeguard these critical water resources. These findings not only provide valuable insights into the chemical and biological status of the tributaries of the Murat River, but also establish a baseline for future research efforts. To build upon this work, it is recommended that subsequent studies expand to encompass the entire Murat River Basin and include comprehensive analyses of anthropogenic impacts and ecological trends over time. In summary, this study revealed that TP, NH_3-N, NO_2-N and NO_3-N concentrations are closely related to diatom indices, indicating that the streams in the study area face significant pollution threats. By addressing the pollution sources and implementing effective management strategies, it is possible to protect and improve the ecological health of the Murat River system for future studies.

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Conflict of Interest

There are no conflicts of interest regarding this research for any of the authors.

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