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Research Article

Investigation of Benthic Macroinvertebrate Fauna and Water Quality of Animal Drinking Water Troughs by Multivariate Statistical Methods: The Case of Şarkışla

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ABSTRACT

This study was conducted in 2022 to investigate the water quality and benthic macroinvertebrate fauna of water troughs in Şarkışla, a district in the city of Sivas. Fifteen stations were selected from the most used water troughs in the district and sampling was carried out in the spring, summer, and autumn seasons during peak agricultural activities. As a result, a total of 17 taxa were identified: 4 taxa belonging to Oligochaeta, 6 species belonging to Chironomidae, 2 taxa belonging to Amphipoda, and one each belonging to Gastropoda, Hemiptera, Coleoptera, Ostracoda and Trichoptera larvae. All taxa identified are new records for the study area. In addition to benthic sampling, some physicochemical parameters of water (water temperature, pH, electrical conductivity, dissolved oxygen, total hardness, calcium, magnesium, chloride, salinity, total dissolved solids, phosphate, sulphate, nitrate nitrogen, nitrite nitrogen) were also analyzed. The similarity of the stations in terms of physicochemical parameters was analyzed by utilizing the Bray-Curtis similarity analysis. Accordingly, stations 2 and 4 were found to be the most similar, by 96.91%, and stations 3 and 13 were found to be the most different, by 66.46%. In addition, the relationship between the investigated physicochemical parameters was analyzed using the Pearson and Spearman Correlation Analysis. The relationship between the species and physicochemical parameters was revealed using the CCA Analysis.

Keywords: Water troughs, benthic macroinvertebrates, physicochemical parameters, statistical methods

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INTRODUCTION

Water troughs are artificially transformed examples of natural water sources. Water troughs are found all over Turkey. Sometimes they are located in villages and sometimes they are found on the roadsides. They were first built to meet the water needs of animals. They can also be used to control water flow, agricultural irrigation, drinking water, and groundwater (Külköylüoğlu et al., 2013; TODAİE, 2011). Water is vital for all living creatures on this planet. In animals, body temperature regulation, nutrient uptake, and waste removal occur with water. Water troughs are artificial water structures created to meet the water needs of animals. They are open-water storage structures of various sizes to accumulate and hold water for animal consumption (Denktaş, 2000; Tay, 2011). These structures are an important source of water for domestic cattle and sheep in cultivated areas and also for wild animals such as wolves, deer, rabbits, birds, etc. in rural and wild areas (Özer, 2010). These water structures, especially in rural areas, are very important to meet the water needs of animals while grazing. Depending on the number of animals relying on the water trough, they can be of different sizes. Water troughs are sometimes located in forested areas, sometimes on higher parts of the landscape, and sometimes on roadsides. The water in these structures is open to contamination. Especially in the summer months algae layers can form on the inside of the water troughs, due to increased weather temperature and stagnation of the water body.

Benthic macroinvertebrates are often used as indicators of the biological status of water bodies. They are reliable indicators as they spend all or most of their life in water. They are easy to collect due to their high tolerance of pollution (Kazancı et al., 1997). Benthic macroinvertebrates are usually found attached to rocks and vegetation, or they are buried in the sand and sediments at the bottom of the water trough.

To date, studies conducted on water troughs belong to Özkan (2006a; 2006b), Külkoylüoğlu ve ark. (2012), Külköylüoğlu et al. (2013), Başak et al., (2013); Külköylüoğlu et al., (2017); Özer & Dikmen (2021); Ataman et al., 2023; Sanbur (2023).

This study aims to determine the water quality and benthic macroinvertebrate fauna of water troughs in the district of Şarkışla using multivariate statistical analyses.

MATERIALS AND METHODS

Study area

Şarkışla is located in the southwest of Sivas province, within the borders of the Upper Kızılırmak region of central Anatolia. Its surface area is 2250 km wide and is at an altitude of 1180 m above sea level.

Şarkışla is the 7th largest district in terms of surface area among the 17 districts of Sivas (https://sarkisla.gov.tr). The economy of Şarkışla is based on agriculture and animal husbandry. The district offers a rich variety of agricultural products due to the presence of large agricultural land and agricultural basins. Field crops include cereals, fodder crops, industrial crops, and edible legumes. Sugar beet and potatoes are among the most cultivated crops. The district creates a suitable environment for animal husbandry with its climate and the presence of pasture areas. Cattle and ovine breeding is common in the district (Oran Kalkınma Ajansı, 2017). Animal husbandry is intensively practiced in the region where this research was conducted. Natural water troughs are made of concrete, metal or wood and are generally rectangular in shape. Water troughs exist for the benefit of both humans and animals.

The coordinates of the selected sampling stations and information about the water troughs are detailed in Table 1.

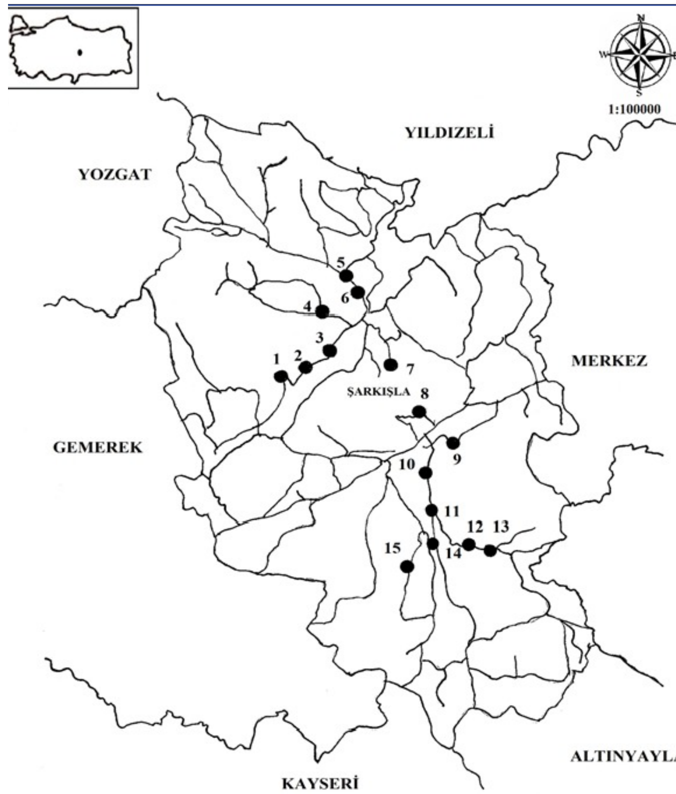

Figure 1. Study area and sampling locations.

Figure 2. Two-partition concrete water trough.

Sampling

The study was carried out at 15 stations in the spring, summer and autumn of 2022, during peak agricultural activity. The stations could not be reached in winter due to bad weather conditions. For this reason, sampling could not be performed during the winter season. pH levels, total dissolved solids, and electrical conductivity of the water samples were measured and recorded during the field study. To analyze other physicochemical parameters, water samples were taken in dark-coloured glass bottles of 1 liter. At the same time as taking water samples, benthos samples were also collected from the bottom part of the water troughs using hand mud scoops of different sizes. The samples were stored and preserved with 70% ethyl alcohol.

The physicochemical parameters of the water were measured using various titrimetric and spectrophotometric methods (Egemen & Sunlu, 1999).

The benthos samples brought to the laboratory were separated from the debris and placed in 70% ethyl alcohol for species iden-

Table 1. Geographical coordinates and information about the water troughs sampled.

Though Number	Stations	Coordinates	Information about the water troughs
1	Çiçekliyurt	39°26'00"N 36°17'58"E	2- partitions concrete water trough
2	Alaçayır	39°27'08"N 36°19'48"E	3- partitions metal water trough
3	İlyashacı Village	39°27'46"N 36°19'58"E	2- partitions concrete water trough
4	Emlakkaracaören	39°29'24"N 36°2128"E	Karacaören Meryemin Ahmet Fatma Cemal Koçtürk Hayratı, 4- partitions concrete water trough
5	Akdağmadeni Şarkışla roadside water trough	39°25'50"N 36°24'19"E	2- partitions concrete water trough, surrounded by agricultural land
6	Belen Tepesi roadside water trough	39°25'04"N 36°24'01"E	Muhlis Doğan Hayratı, 3- partitions concrete water trough
7	Cemel Altınyayla road	39°19'12"N 36°30'11"E	5- partitions concrete water trough, surrounded by agricultural land
8	Elmalı Village entrance	39°26'00"N 36°17'58"E	3- partitions concrete water trough, surrounded by agricultural land
9	Maksutlu Village	39°21'38"N 36°27'40" E	Kalembey Oğullarından Kaya Kızı Nalan Polat Hayratı, 2- partitions concrete water trough
10	Üyük (Hüyük) Village	39°22'21"N 36°17'58"E	5- partitions concrete water trough
11	Döllük Village	39°20'80"N 36°27'89"E	2- partitions concrete water trough
12	Cemel roadside water trough	39°18'16"N 36°27'36"E	Asım oğlu Ahmet Demirci ve Cemel Belediyesi Hayratı, 4- partitions concrete water trough, surrounded by agricultural land
13	Cemel Village road	39°20'09"N 36°26'20"E	4- partitions concrete water trough. In addition, daily agricultural labourers live in the surrounding area.
14	Hamlar	39°17'55"N 36°27'24"E	4- partitions concrete water trough, surrounded by agricultural land. Wheat, barley, chickpea, and sunflower are among the most cultivated crops.
15	Aşılık (Osmanpınarı)	39°16'08"N 36°27'48"E	4- partitions concrete water trough, surrounded by agricultural land. Wheat and barley are among the most cultivated crops.

tification. The collected benthos samples were identified to the smallest taxonomic group possible. Kathman & Brinkhurst (1998), Milligan & Michael (1997) and Timm (1999) were consulted the for identification of Oligochaeta. Oliver et al., (1978), Saether (1980), Cranston (1982), Pinder & Reiss (1983), and Fittakau & Roback (1983) were consulted for the identification of Chironomidae. For the identification of Amphipoda, the help of subject experts was obtained.

Statistical analyses

All obtained results were transformed by LogBase10 in Microsoft Office Excel 2010 and SPSS 9.0 for Windows to use statistical techniques (Krebs, 1999). The relationship between the physicochemical parameters was evaluated by applying the Spearman and Pearson Correlation Analysis (Krebs, 1999). The similarity of physicochemical parameters in terms of stations was analyzed by Bray-Curtis Cluster analysis using BioDi-versity Pro 2.0 (McAleeceet al., 1997). The statistical relationship between the benthic macroinvertebrates and environmental parameters Canonical Correspondence Analysis (CCA) was determined using the Past Version 3.14. (Hammer et al., 2001).

RESULTS AND DISCUSSION

A total 17 taxa were identified in this study. These included four taxa belonging to Oligochaeta, six to Chironomidae, two to Amphipoda, and one each to Gastropoda, Hemiptera, Coleoptera, Ostracoda and Trichoptera larvae. All taxa identified are new records for the study area.

In the study, the habitat and station information on taxa as well as information about seasons is as follows. The highest number of taxa was found in the spring season (14 taxa), followed by the summer (10 taxa) and finally the autumn (7 taxa). *Nais elinguis* are abundant in organically polluted waters. They can be found in fast-flowing rivers as well as in muddy, foul-smelling, poorly oxygenated, and cold waters under wide environmental conditions (Timm, 2003). In the study, *Nais elinguis* were found in the spring season at stations 4 and 6. *Nais simplex* is an almost cosmopolitan species, found in fresh waters (Timm et al., 2002). *N. simplex* was found in water samples collected from soft muddy ground. *N. simplex* was found only at station 11 in the spring and summer seasons. *Chaetogaster diaphanus* is found among plants in brackish and fresh waters and in rivers with generally clear water. It is a predatory species that eats small invertebrates such as Oligochaetae, Chironomidae larvae, Cladocera and Copepoda (Timm, 2003). *C. diaphanus* was found in the spring season at station 11. Timm (2013) reported that species belonging to the genus *Potamothrix* sp. are present in freshwater, brackish water and euryhaline forms. *Potamothrix* sp. was found in the spring season at station 13.

Chironomus riparius is a common species and usually lives in eutrophic conditions (Thienemann, 1954). *C. riparius* was found at stations 2, 6, 9, 11, 12 in the spring season (Table 2). It was found at stations 1, 8, 13, 14 in the summer season, and at station 2 in the autumn season (Table 2). The most common species encountered during sampling was *Chironomus anthracinus* (Table 2). This species is the most tolerant species of the Chironomidae family and is very common (Taşdemir et al., 2009). In this study, *C. anthracinus* was found in all three seasons and in all stations. *C. anthracinus* was found at stations 3, 5, 6, 8, 9, 10, 11, 12, 14 and 15 in the spring season (Table 2); at stations 1, 2, 4, 7, 8, 9, 12, 13, 14 and 15 in the summer season (Table 2); and at stations 2, 3, 4, 5, 10, 12 and 13 in the autumn season (Table 2). *Chironomus viridicollis* lives in the muddy parts of stagnant waters (Özkan 2006a). In the study, it was detected at stations 8 and 9 in the spring season and at station 8 in the summer season (Table 2). Taşdemir et al., (2010) reported that *Cricotopus intersectus* was found in stagnant waters. In this study, *C. intersectus* were found at stations 1, 3, 5, 9, 10, 11, 12 in the spring season; at stations 1, 2, 3, 5, 9, 10, 11, 14 in the summer season, and at station 8 in the autumn season (Table 2). Özkan (2007) reported that *Paracladius conversus* is seen on mud-aquatic stream plants. *P. conversus* was found at station 3 in the spring and at station 7 in the summer seasons. Özkan (2007), reported that *Tanytarsus gregarilus* is found in mud in stagnant waters, and found in sandy, muddy, and stony ground in streams. *T. gregarilus* was found at stations 3, 6, 9, 13, 14, 15 in the spring season (Table 2). In the summer season, it was found at stations 1, 7, 8, 14, 15 (Table 2).

Gastropods are more abundant in spring and summer. Their tolerance to very hard and salty waters is quite high (Robert & Diilon, 1999). Gastropoda individuals were found at station 8 in the spring; at station 15 in the summer; and at stations 12 and 13 in the autumn (Table 2). *Niphargus* sp. is reported to be the largest of all freshwater amphipod genera (Väinölä et al., 2008). Usually, these individuals inhabit caves or groundwater (Karaman & Ruffo, 1986; Sket, 1999). *Niphargus* sp. was found at station 1 in the autumn season. *Gammarus pseudocsyritia* has a wide tolerance range to temperature (usually 5–21 °C), so it was reported that this adaptation to different water temperatures is the main reason for its wide presence (Zamanpoore et al., (2011). *G. psedosyriacus* was found at station 5 in the the spring season (Table 2). Hemipterans are found in lentic habitats or in backwater or pool areas of streams (http://lakes.chebucto.org/). Hemiptera was found at station 12 in the autumn season. Coleopterans larvae are organisms sensitive to pollution. They can be found in moderately polluted waters (Haldar et al., 2016). Coleoptera was found at station 5 in the spring season (Table 2).

Ostracods live in all kinds of aquatic environments including the base of oceans, in rivers, in lakes and even in swamps. Some ostracods live in temporary water bodies and can survive when the pond dries up in summer (www.bgs.ac.uk). Ostracoda was found

Table 2. Benthic macroinvertebrate taxa identified from the water troughs and their seasonal distribution according to stations.

Taxonomic Groups /Seasons	Spring Season	Summer Season	Autumn Season
Oligochaeta			
Nais elinguis Müller, 1773	4,6	-	-
Nais simplex Piguet, 1906	11	11	-
Chaetogaster diaphanus (Gruithuisen, 1828)	11	-	-
Potamothrix sp.	13	-	-
Chironomidae			
Chironomus riparius Meigen, 1804	2,6,9,11,12	1,8,13,14	2
Chironomus anthracinus Zetterstedt, 1860	3,5,6,8,9,10,11,12,14,15	1,2,4,7,8,9,12,13,14,15	2,3,4,5,10,12,13
Chironomus viridicollis Wulp, 1877	2,9	8	-
Cricotopus intersectus (Staeger,1839)	1,3,5,9,10,11,12	1,2,3,5,9,10,11,14	8
Paracladius conversus (Walker, 1856)	3	7	-
Tanytarsus gregarilus Kieffer, 1909	3,6,9,13,14,15	1,7,8,14,15	-
Gastropoda	8	15	12,13
Amphipoda			
Niphargus sp.	-	-	1
Gammarus psedosyriacus Karaman&Pinkster, 1977	5	-	-
Hemiptera	-	-	12
Coleoptera	5	-	-
Ostracoda	-	7,10	3,7,12,13
Trichoptera larvae	3,8	7	-
Total number of taxa	14	10	7

at stations 7 and 10 in the summer season (Table 2). It was found at stations 3, 7, 12 and 13 in the autumn season (Table 2). Trichopterans are indicator species of clean waters. They live in all kinds of aquatic environments, including rivers, lakes, ponds, and swamps (Haldar et al., 2016). Trichoptera larvae were found at stations 3 and 8 in the spring and at station 7 in the summer (Table 2). The benthos samples from the water troughs and the detected species are given in Table 2.

During the study period, water temperature values were measured between 6 °C (spring season, stations 3, 7, 10, 12, 13) and 16.5 °C (summer season, station 13) (Table 3). pH values were found to vary between 7.23 (spring season, station 13) and 8.67 (autumn season, station 11) (Table 3). Electrical conductivity values were found to vary between 359 µS/cm (autumn season, station 7) and 994 µS/cm (spring season, stations 8 and 13) (Table 3). During the study period, dissolved oxygen value was measured between 1.52 mg/L (autumn season, station 12) and 6.66 mg/L (spring season, stations 5 and 15) (Table 3). TH values were recorded between 18 FS° (spring season, station 15) and 37 FS° (spring season, station 2). Ca values were found to vary between 5.20 mg/L (autumn season, station 11) and 123.9 mg/L (summer season, station 5) (Table 3). Mg values were found to vary between 1.22 mg/L (spring season, station 12) and 34 mg/L (summer season, station 13) (Table 3). Cl values were found to vary between 0.99 mg/L (summer season, stations 2 and 3) and 53.9 mg/L (summer season, station 10) during the study period (Table 3). Salinity values were measured between 0.008 ‰ (autumn season, 2nd, 3rd, 6th stations) and 0.09 ‰ (spring, 10th station) (Table 3). TDS values were found to vary between 140 ppm (spring, 7th and 10th stations) and 486 ppm (spring season, 8th station) (Table 3). PO_4 values varied between 0.0005 mg/L (autumn season, station 1) and 0.87 mg/L (autumn season, station 11) (Table 3). It was found that the measured SO_4 values varied between 0.12 mg/L (autumn, station 1) and 5.34 mg/L (autumn season, station 8) (Table 3). NO_3-N values varied between 5.83 (summer season, 11th station) and 54.5 mg/L (summer season, 13th station) (Table 3). The NO_2-N values measured in the study varied between 0.002 mg/L (spring season, 11th station) and 0.65 mg/L (summer season, 4th station). (Table 3). Some physicochemical data measured from the water troughs according to seasonal average values of the stations are presented in Table 3.

According to TSWQR (2016), 1st class refers to high-quality or "very good" water. This quality of water can be used for animal production and farm needs. When the results obtained are evaluated, it is determined that all stations are of 1st class quality in terms of pH, sulfate and water temperature (SKKY, 2004). In terms of electrical conductivity, the stations are between 1st and 2nd class water quality (TSWQR, 2016). In terms of NO_3-N, it was determined that stations 2, 5, 8, 9, 10, 11 and 12, were of 3rd class water quality and the other stations were of 4th class water quality. The high NO_3-N values of the waters may be attributed to the presence of agricultural land around some stations. Leaving animal faeces in grazing areas can also increase the amount of nitrate in groundwater. In terms of dissolved oxygen, stations 3, 4 and 8 are in the 4th class water quality grade and the other stations are of between 2nd and 3rd class water quality. When the chloride values in the water samples were examined, it was found that stations 9 and 10 were between 1st and 2nd class water quality grades and the other stations were of 1st class water quality (TSWQR, 2016).

D.O., Ca, Salinity and NO_3-N values were found to be high in the spring season. W.T., pH, E.C., Mg, Cl, PO_4, SO_4 were found in high amounts in the summer season (Table 4). As the air temperature increases in the summer, the water temperature also increases. The heated water dissolves the rock layers through which it passes and causes both pH and E.C. values to be higher. It was determined that T.H., TDS, NO_2-N values were high in the autumn season. Average values according to seasons and water quality parameters are given in Table 4.

When the average physicochemical values of the sampling stations are compared using the Bray-Curtis similarity index it is found that stations 2 and 4 are the most similar stations (96.91%), followed by station 9 (96.72%). Stations 3 and 13 are the least similar stations (66.46%) (Figure 3). Stations 2 and 4 are the most similar stations. It is very likely that the water coming to these stations comes from the same source. The elevation of the 3rd station is higher than that of the 13th station. The difference in elevation may impact water properties depending on the rock layers the water is passing through.

The average physicochemical values across the three seasons are also analyzed using the Bray-Curtis similarity index. Accordingly, spring and summer seasons were 95.90% similar, followed by the autumn season with 95.89% similarity to both spring and summer. Summer and autumn seasons were found to be the least similar seasons with a rate of 95.82% (Figure 4). It was determined that the similarity is very high across all three seasons.

The taxa and physicochemical values were also analyzed utilizing the CCA Analysis. The eigenvalues of the first two axes were calculated as 0.486 and 0.388, respectively. In the analysis, the two axes explain 40.59% of the variance of the species, 22.56% (Axis 1) and 18.03% (Axis 2). The distributions of *N. elinguis*, *Potamothrix* sp., and Gastropoda were affected by NO_2-N, NO_3-N, TDS, E.C., and salinity. Environmental variables do not affect the distributions of *C. intersectus*, *P. conversus*, *G. psedosyriacus*, Coleoptera, and Trichoptera. While W.T., Cl, PO_4, D.O., SO_4, and pH are effective in the distribution of *C. riparius*, *C. viridicollis*, *N. simplex*, *C. diaphanus*, *Niphargus* sp., Ostracoda, and Hemiptera; T.H., Mg, and Ca are not effective. The species *C. anthracinus* is affected by T.H., Mg, and Ca (Figure 5).

In addition, Pearson correlation analysis was applied to the normally distributed physicochemical values. Accordingly, a significant positive correlation was found between Ca and TH levels. Similarly, a significant negative correlation was found between pH and Ca levels. The relationship and correlation coefficients between the physicochemical parameters analyzed are given in Table 5.

Finally, the Spearman correlation analysis was applied to the values that did not show a normal distribution. Accordingly, a significant negative correlation was found between D.O. and NO_2-N; NO_2-N and PO_4; W.T. and D.O. There is a significant positive correlation be-

Table 3. Physicochemical data measured at sampling stations in terms of seasons.

Season	Parameters	Unit	1st	2 nd	3 rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13 th	14 th	15 th
Spring Season	W.T.	°C	7	7.5	6	6.5	7	7	6	7	6.5	6	7	6	6	6.5	6.5
	pH		7.85	7.70	7.89	7.73	7.64	7.69	7.72	7.68	7.63	7.78	7.83	7.55	7.23	7.40	7.79
	E.C.	µs/cm	398	652	366	645	521	394	362	994	455	701	381	398	994	655	408
	D.O	mg/L	4.76	4.18	3.80	3.42	6.66	4.32	5.71	2.85	4.76	5.90	5.52	5.71	5.33	6.09	6.66
	T.H	°F	20	37	19	32.8	27.6	21.6	20	35.6	27.8	27	18.6	31.2	35.2	28.4	18
	Ca	mg/L	48	59.3	38.4	83.36	96.19	73.74	68.13	102.6	84.16	83.36	50.55	76.15	103	74.54	48.08
	Mg	mg/L	6.83	5.42	4.73	12.29	16.68	12.68	11.7	16.29	13.7	11.36	7.75	1.22	16.48	11.22	6.3
	Cl	mg/L	6.99	6.99	2.99	25.99	2.99	1.99	3.99	8.99	27.99	3.99	4.99	23.99	19.99	21.99	7.99
	Salinity	‰	0.02	0.01	0.03	0.03	0.02	0.01	0.01	0.04	0.03	0.09	0.03	0.05	0.07	0.06	0.03
	TDS	ppm	183	321	181	316	248	173	140	486	250	245	140	249	247	249	152
	PO_4	mg/L	0.62	0.20	0.62	0.32	0.39	0.67	0.71	0.74	0.43	0.38	0.61	0.49	0.67	0.48	0.78
	SO_4	mg/L	0.08	0.59	0.20	1.38	1.10	0.26	0.48	4.80	1.16	0.99	0.12	1.72	3.20	1.63	0.34
	NO_3-N	mg/L	52.7	24.9	37.6	34.28	10.94	29.06	33.04	40.04	26.66	23.65	30.16	18.56	17.04	28.17	29.9
	NO_2-N	mg/L	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.003	0.01	0.002	0.02	0.01	0.02	0.01
Summer Season	Parameters	Unit	1st	2 nd	3 rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13 th	14 th	15 th
	W.T.	°C	16	15.5	16	15	15	14.5	16	15	15.5	15	14.5	16	16.5	15	15.5
	pH		7.91	7.71	7.98	7.86	7.81	7.72	7.91	7.86	7.80	7.91	7.70	7.88	7.86	7.94	7.90
	E.C.	µs/cm	395	644	370	641	552	458	788	641	728	705	378	640	737	643	412
	D.O	mg/L	3.04	2.66	2.47	1.90	2.09	3.72	4.37	1.52	5.71	4.76	3.61	3.80	4.56	4.76	5.14
	T.H	°F	20	35.4	18.8	32	29.8	21.7	40	29	26.8	29	17.9	30.4	34	30	19
	Ca	mg/L	48.09	68.13	40.08	80.16	123.9	80.15	60.92	91.3	20.04	113.8	48.7	74.54	97.7	61.7	48.8
	Mg	mg/L	6.83	7.95	5.17	11.71	16.4	13.60	5.08	15.1	1.64	29	9.53	30.4	34	30	19
	Cl	mg/L	2.99	0.99	0.99	1.99	8.99	4.99	4.99	20.99	36.9	53.9	2.99	26.9	31.9	26.9	9.99
	Salinity	‰	0.008	0.04	0.02	0.05	0.03	0.009	0.01	0.05	0.02	0.04	0.03	0.02	0.02	0.04	0.02
	TDS	ppm	158	250	161	283	222	334	293	429	330	319	158	239	317	288	179
	PO_4	mg/L	0.65	0.18	0.64	0.37	0.41	0.69	0.70	0.73	0.55	0.50	0.87	0.50	0.68	0.53	0.79
	SO_4	mg/L	5.13	1.46	2.40	1.73	1.01	0.13	0.35	3.71	0.97	0.73	0.36	1.51	2.78	1.59	0.74
	NO_3-N	mg/L	32.79	21.79	33.04	35.9	13.24	26.52	30.8	13.7	14.1	6.08	5.82	12.4	54.5	26.4	39.8
	NO_2-N	mg/L	0.04	0.05	0.009	0.65	0.04	0.03	0.04	0.32	0.04	0.03	0.02	0.04	0.04	0.05	0.04

W.T: Water Temperature. E.C: Electrical Conductivity. D.O: Dissolved Oxygen. T.H: Total Hardness. TDS: Total Dissolved Solids

Table 3 (Continue). Physicochemical data measured at sampling stations according to seasons.

	Parameters	Unit	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
Autumn Season	W.T.	°C	8	8.5	8	9	9.5	9.5	8.5	10	10.5	10	10	11	11	10.5	11
	pH		7.85	7.70	7.82	7.75	7.74	7.52	7.61	7.79	7.76	7.80	8.67	7.62	7.66	7.80	7.70
	E.C.	µs/cm	404	612	365	567	509	416	359	886	737	581	395	639	656	630	442
	D.O	mg/L	2.66	2.47	2.28	1.71	2.09	3.23	3.04	3.80	2.47	2.85	3.42	1.52	1.90	2.28	2.66
	T.H	°F	26.2	38	22.4	37	30	26.8	24.4	35	31	24.4	20.6	30.6	32.6	32	24.4
	Ca	mg/L	57.7	41.68	44.08	72.14	89.77	86.57	72.14	97.79	53.70	62.52	5.20	80.16	84.96	65.73	57.71
	Mg	mg/L	7.66	0.89	5.27	8.54	14.53	14.53	12.68	15.27	5.52	9.90	8.70	12.05	12.84	8.54	6.25
	Cl	mg/L	7.99	8.99	7.99	2.99	8.99	7.99	10.99	9.99	28.99	44.98	3.99	12.99	13.99	14.99	2.99
	Salinity	‰	0.01	0.008	0.008	0.01	0.01	0.008	0.02	0.01	0.05	0.02	0.01	0.01	0.02	0.05	0.03
	TDS	ppm	202	306	182	283	254	208	179	443	368	290	305	319	348	178	300
	PO_4	mg/L	0.0005	0.01	0.006	0.004	0.01	0.001	0.003	0.012	0.005	0.003	0.02	0.012	0.008	0.009	0.01
	SO_4	mg/L	0.12	0.06	0.09	0.93	1.07	0.01	0.17	5.34	1.44	0.65	0.19	1.66	3.33	1.83	1.27
	NO_3-N	mg/L	17.04	10.96	17.93	13.94	15.82	27.79	0.90	7.75	12.39	11.95	15.72	11.51	30.20	10.84	24.34
	NO_2-N	mg/L	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.08	0.05	0.05	0.05	0.05
Average values of the stations	Parameters	Unit	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
	W.T.	°C	10.3	10.5	10	10.1	10.5	10.3	10.1	10.6	10.8	10.3	10.5	11	11.1	10.6	11
	pH		7.87	7.89	7.89	7.78	7.73	7.64	7.74	7.77	7.73	7.83	8.06	7.68	7.58	7.71	7.79
	E.C.	µs/cm	399	636	367	618	527	423	503	840	640	662	385	559	796	643	421
	D.O	mg/L	3.48	3.10	2.85	2.34	3.61	3.75	4.37	2.72	4.31	5.50	4.18	3.67	3.93	4.37	4.82
	T.H	°F	22.06	36.8	20.06	33.93	29.13	23.36	28.13	33.2	28.53	26.8	19.03	30.73	33.93	30.13	20.46
	Ca	mg/L	51.26	56.37	40.85	78.55	103.2	80.15	67.06	97.23	52.63	86.56	34.81	76.95	95.22	67.32	51.53
	Mg	mg/L	7.10	4.75	5.05	10.84	15.87	13.60	9.82	15.53	6.95	16.7	8.66	14.55	21.10	16.58	10.51
	Cl	mg/L	5.99	5.65	3.99	10.32	6.99	4.99	6.65	13.32	31.29	34.29	3.99	21.29	21.96	21.96	6.99
	Salinity	‰	0.01	0.01	0.01	0.03	0.02	0.009	0.01	0.03	0.03	0.05	0.02	0.02	0.03	0.05	0.02
	TDS	ppm	181	292	174	294	241	238	204	452	316	284	201	269	304	238	210
	PO_4	mg/L	0.42	0.13	0.42	0.23	0.27	0.45	0.35	0.49	0.32	0.29	0.50	0.33	0.45	0.34	0.52
	SO_4	mg/L	1.77	0.70	0.89	1.34	1.06	0.13	0.33	4.61	1.19	0.79	0.22	1.63	3.10	1.68	0.78
	NO_3-N	mg/L	34.17	19.21	29.52	28.04	13.33	27.79	21.58	20.49	17.71	13.89	17.23	14.15	33.91	21.80	31.34
	NO_2-N	mg/L	0.03	0.03	0.01	0.23	0.03	0.03	0.03	0.12	0.02	0.02	0.03	0.03	0.03	0.04	0.03

W.T: Water Temperature. E.C: Electrical Conductivity. D.O: Dissolved Oxygen. T.H: Total Hardness. TDS: Total Dissolved Solids

Table 4. Water quality parameters of water troughs according to seasonal average values

	Spring	Summer	Autumn	Average
W.T. (°C)	6.57	15	9.7	10.42
SKKY, 2004	**I**	**I**	**I**	**I**
pH	7.67	8	7.8	7.82
TSWQR,2016	**I**	**I**	**I**	**I**
E.C.(µs/cm)	554.93	582	546.5	561.14
TSWQR,2016	**I-II**	**I-II**	**I-II**	**I-II**
D.O (mg/L	5.04	4	2.6	3.88
TSWQR 2016	**II-III**	**II-III**	**IV**	**II-III**
T.H (°F)	26.65	28	29	27.88
Ca (mg/L)	72.64	71	64.8	69.48
Mg (mg/L)	10.31	16	9.5	11.94
Cl (mg/L)	11.46	16	12.6	13.35
SKKY, 2004	**I**	**I**	**I**	**I**
Salinity (‰)	0.04	0.01	0.01	0.02
TDS (ppm)	238.67	264	277.7	260.12
PO_4 (mg/L)	0.54	1	0.01	0.52
SO_4 (mg/L)	1.2	2	1.2	1.47
SKKY, 2004	**I**	**I**	**I**	**I**
NO_3-N (mg/L)	29.11	24	15.3	22.80
TSWQR,2016	**IV**	**IV**	**II-III**	**IV**
NO_2-N (mg/L)	0.01	0.01	0.1	0.04
SKKY, 2004	**II**	**II**	**IV**	**IV**

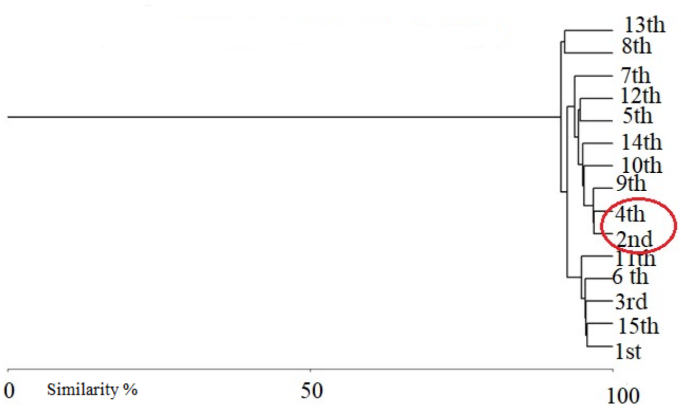

Figure 3. Bray Curtis Similarity dendogram in terms of physicochemical values.

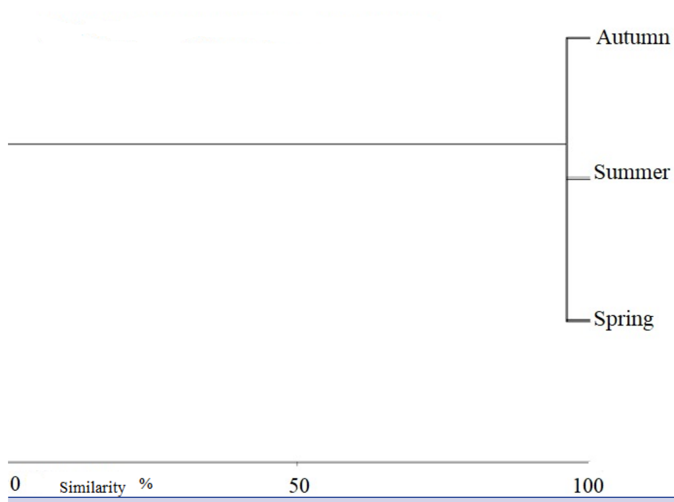

Figure 4. Bray-Curtis similarity dendogram in terms of seasons.

tween W.T. and NO_2-N; D.O. and PO_4; E.C. and Cl; E.C. and SO_4; E.C. and TDS; Cl and salinity; Cl and TDS. As temperature increases in aquatic systems, oxygen concentration decreases. This causes the release of phosphorus from the sediment (IPCC, 2008). The results support the literature. Significant positive correlation was found between E.C. and Cl, and between SO_4 and TDS. The conductivity of water increases in the presence of inorganic dissolved solids such as Cl, NO_3, SO_4 and PO_4 anions or Na, Mg, Ca, Fe and Al cations (Spellman, 2003). Salinity consists of four cation groups such as Ca, Mg, Na, K and four aion groups such as HCO_3, CO_3, SO_4 and Cl (Egemen & Sunlu 1999). Cl, SO_4 and TDS were all found to be significantly positively correlated with E.C. The results are consistent with the literature. Correlation coefficients are given in Table 6.

When the study is compared with previous studies, it can be said that some similar features are observed. Özkan (2006a) taxonomically examined samples from six different localities in Bozcaada between 1999-2002. The same study also identified a total of 14 species and made diagnostic keys of the species. All species are reported as new records for Bozcaada. *Chironomus salinarius* K was reported as a new species for the Chironomidae fauna of Turkey. *C. thummi*, *C. anthracinus*, *C. viridicollis*, *Einfeldia pagana* and *Polypedilum aberrans* were recorded as species emerging from the water troughs. Özkan (2006a) reported that *C. ripar-*

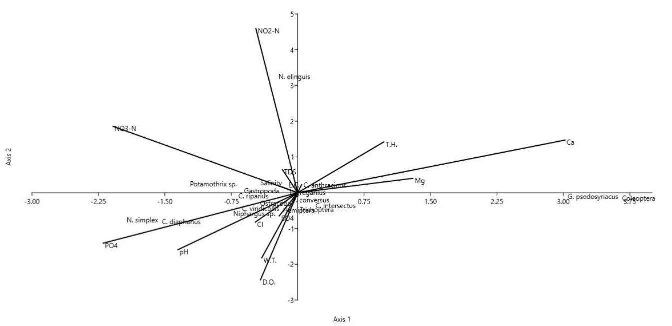

Figure 5. CCA Analysis of physicochemical values with taxa.

Table 5. Pearson Correlation Analysis.

	Ca	TH	pH	NO_3-N
Ca	1			
TH	.468**	1		
pH	-.500**	-.294	1	
NO_3-N	-.084	-.173	.092	1

****: correlation is significant at 0.01 level (p < 0.01);**
-: no statistically significant correlation was detected
**. Correlation is significant at the 0.01 level (2-tailed).

Külköylüoğlu et al. (2013) collected samples from water troughs in Bolu, Erzincan, Gaziantep, Kahramanmaraş, Ordu and Van provinces at different times between 2006 and 2010. They identified 32 Ostracoda species in total from 105 water troughs and investigated the composition and diversity of these species. The species belonging to Ostracoda were reported as *Heterocypris incongruens*, *Ilyocypris bradyi*, *Psychrodromus olivaceus*, *Candona neglecta*. The authors of the above-mentioned study identified water troughs as important structures to be studied due to their high-altitude locations and the unique species diversity to be found in them. They stated that zooplankton, phytoplankton and molluscs of different taxonomic groups found in water troughs should also be studied. In this study, ostracoda were found at stations 7 and 10 in the summer season and at stations 3, 7, 12 and 13 in the autumn season. However, the exact species could not be identified.

Başak et al. (2013) collected samples belonging to Copepoda and Cladocera groups from zooplankton in Ankara province. They reported 12 new zooplankton species for Ankara. The most common species found was *Eucyclops serrulatus*.

Külkoylüoğlu et al. (2017) investigated the diversity and distribution of Ostracods between Karabük and Düzce provinces. They reported that the most widespread species was *Heterocypris incongruens*.

Table 6. Spearman Correlation Analysis.

	NO_2-N	Mg	D.O.	E.C.	W.T.	Cl	Salinity	SO_4	TDS	PO_4
NO_2-N	1									
Mg	.137	1								
D.O.	-.600**	.069	1							
E.C.	.206	.299*	.010	1						
W.T.	.594**	.175	-.424**	.209	1					
Cl	.110	.330*	.111	.471**	.054	1				
Salinity	.272	.313*	-.055	.292	.356*	.443**	1			
SO_4	.209	.323*	-.170	.527**	.287	.253	.380*	1		
TDS	.371*	.170	-.259	.731**	.231	.421**	.202	.342*	1	
PO_4	-.425**	.155	.488**	-.027	.052	-.116	.031	.129	-.197	1

*: correlation significant at 0.05 level (p < 0.05);
****: correlation is significant at 0.01 level (p < 0.01);**
-: no statistically significant correlation was detected

ius and *C. anthracinus* lived mostly in the muddy bottom of stagnant waters, while *C. viridicollis* lived in the mud of stagnant waters. In this study, *C. riparius*, *C. anthracinus* and *C. viridicollis* species were found. Our study supports the literature in terms of both habitats and species.

Özkan (2006b) reported that *Paracladius conversus* and *Tanytarsus gregarilus* species were observed in stagnant water bodies in Gökçeada. *Paracladius conversus* and *T. gregarilus* were also identified in this study, in line with the larger literature.

In their study, Külkoylüoğlu et al. (2012) investigated whether water troughs constructed as artificial sources are beneficial for biodiversity and for the ecological characteristics of Ostracods in water troughs in some regions of Turkey.

Özer & Dikmen (2021) analyzed water troughs across the world, but especially in Erzurum, Turkey. They classified the water troughs according to type of material, number of sections, aesthetic features, and shapes, and made some suggestions on the protection and development of these structures.

Ataman et al. (2023) investigated the diversity and seasonal cycles of freshwater Ostracoda in man-made water troughs. They reported that *Heterocypris incongruens*, *Heterocypris salina* and *Ilyocypris bradyi* species were found in the water troughs.

Sanbur (2023) investigated the diatom species diversity of rural fountains and water troughs in various regions of Eskişehir. The conclusion of the study showed that 200 diatom taxa from the water troughs had been identified. The researcher reported that diatom diversity was high in the water troughs.

As a result of this multivariate statistical study carried out on water samples collected from 15 water trough stations across the Şarkışla region of Sivas, statistically significant relationships were found showing that altitude and agricultural activity impact water quality. These factors contribute to variations in water quality from the 1st to the 4th water quality grades. Within agricultural activities, the water quality of troughs may deteriorate due to pesticide applications. Pesticides can cause deterioration of groundwater quality and deterioration of the physical, chemical, and biological structure of water through irrigation and precipitation due to rain and snow. In areas where livestock breeding is intensive, other factors polluting groundwater resources should be identified and water troughs should be evaluated based on integrated basin management In order to identify this, it is very important to carry out studies of this kind at regular intervals to monitor the water quality and benthic macroinvertebrate fauna of surface and groundwater resources and to catalogue and maintain the hydrobiological diversity of Turkey.

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Ethics committee approval: Ethics committee approval was not required.

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