Acta Aquatica Turcica

Home Page: https://dergipark.org.tr/actaquatr
E-ISSN: 2651-5474
22(1): 220107, 2026
DOI: 10.22392/actaquatr.1739320

Research Article **Araştırma Makalesi**

Biological Assessment of The Water Quality of Karacaören 1 Dam Lake, Burdur – Türkiye

Edafe Odioko[1,2,*], Zehra Arzu Becer[3]

[1]Department of Aquacultural Engineering, Akdeniz University, Institute of Science, Akdeniz University, Antalya-TÜRKİYE
[2]Department of marine Science, Faculty of Science, Southern Delta University, Ozoro-Delta State-NIGERIA
[3]Department of Basic Fisheries Sciences, Faculty of Fisheries, Akdeniz University, Antalya-TÜRKİYE

*Corresponding Author: edafe.odioko@gmail.com

Received: 10.07.2025 **Accepted:** 15.11.2025 **Published:** 01.03.2026

How to Cite: Odioko, E., & Becer, Z. A. (2026) Biological assessment of the water quality of Karacaören 1 Dam Lake, Burdur-Türkiye. *Acta Aquatica Turcica*, *22*(1), 220107. https://doi.org/10.22392/actaquatr.1739320

Abstract: This study was carried out to evaluate the water quality of Karacaören I Dam Lake using benthic macroinvertebrates with the application of Family Biotic Index (FBI), Biologic Monitoring Working Party Score System (BMWP) and Average Score Per Taxon (ASPT) biotic indices. Benthic macroinvertebrate samples were collected bimonthly between January 2022 and December 2022 from seven sampling sites kick-net methods to collect samples from littoral region and Ekman grab to collect samples from muddy areas. A total of 841 macroinvertebrates belonging to 11 orders and 24 families were identified. The results of the BMWP biotic index showed that the water quality of stations 2, 3, 4, 5, and 6 were moderately polluted by organic substances (class III). In contrast, stations 1 and 7 (class IV) had poor water quality due to pollution from organic substances. ASPT results showed that stations 1, 3, 4, 5, 6, and 7 possessed good water quality (class II) while station 2 possessed moderate level water quality (class III). While the FBI results showed station 1 and 5 water were in excellent condition. The results of this investigation support the assertion that anthropogenic factors have impacted the lake's water quality. Therefore, realizing the planned use of Karacaören I Dam Lake water as a potential source of drinking water is related to adopting protection measures to prevent further deterioration of the water quality.

Keywords
- Biotic index
- Bioindicators
- Human activities
- Macroinvertebrates
- Organic pollution

1. INTRODUCTION

Water quality defines the state of water based on its chemical, physical, and biological features for specific uses like drinking, swimming, and agriculture. As a biological component of water quality, benthic macroinvertebrate communities with their long-life cycles being a good indicator for putting forward environmental problems as a case of pollution in a water body. Macroinvertebrates are important organisms of aquatic ecosystems, functioning both as decomposers of organic matter and as the primary food source for various other aquatic life, including invertebrates, fish, and some birds. This key ecological role is why they used in the basis of many biotic indices. (Callisto et al., 2001).

The usefulness of benthic macroinvertebrates as bioindicators places in a middle ground compared to faster-reacting organisms (phytobenthos, phytoplankton, zooplankton) and slower-reacting ones (fish) (Segnini, 2003). Biotic indices are used to evaluate the sensitivity of benthic macroinvertebrates to pollution in aquatic systems by taking into account the composition and abundance of benthic macroinvertebrates. Biotic indices are expressed by numerical scores.

Various researchers such as Bettinetti et al. (2012), Šidagytė et al. (2013), Zeybek et al.

This paper is published by Isparta University of Applied Sciences, Eğirdir Fisheries Faculty under Creative Commons Attribution 4.0 International (CC BY 4.0) license. http://creativecommons.org/licenses/by/4.0/

(2014), Kökçü (2016), Albayrak and Özuluğ (2016), Teksoy et al. (2017), Spyra et al. (2017), Kaban et al. 2018, Kilçik (2020), Dzhurtubaev et al. (2021), Kızılkaya (2022) have used different biotic indices to evaluate the health status of different water bodies in Türkiye and other countries.

Karacaören I Dam Lake which is located at the intersection of the borders of Antalya province with Burdur and Isparta (Gülle, 2005) is the study site. This dam lake originally constructed for the purposes of irrigation, flood control and hydrothermal electricity generation (Süel et al., 2018) is now considered as a potential source of drinking water as the population of the nearby provinces continue to expand. This rapid population growth has pressured on existing water utility and other natural resources (DSİ, 2015).

However, there are concerns about the suitability of this water body for human consumptions due to organic pollutions emanating from agricultural activities in nearby communities, cage fish farming in the dam lake and domestic waste such as canalization that finds its way into the Karacaören I Dam Lake. There are various studies on biological assessment of water quality of other lakes, dams and other water bodies in the Mediterranean region of Türkiye, however there is limited information on biological assessment of the water quality of Karacaören I Dam Lake. Hence, this study is aimed to determine the level of organic pollution of the Karacaören I Dam Lake by assessing the diversity of benthic macroinvertebrates and three biotic indices such as Family Biotic Index (FBI), Biologic Monitoring Working Party Score System (BMWP) and Average Score Per Taxon (ASPT).

2. MATERIAL and METHODS

2.1. Study Location

This research was conducted in Karacaören I Dam Lake, Burdur. Karacaören I Dam Lake is in the Mediterranean region of Türkiye and its latitude and longitude are 37.3974° N and 30.8556° E, respectively (Becer and Ikiz, 2008; Becer and Karabacak, 2011., Becer et al., 2018). The dam was constructed in 1989 on the Aksu River for irrigation, flood prevention and energy generation. It has a volume of 1234 hm^3 and a reservoir area of 4550 ha (Süel et al., 2018). Karacaören I Dam Lake serves as a water source for the villages of Sütçüler district such as Çandır, Melikler, Şeyhler and the surrounding agricultural areas (Süel et al., 2018). The primary sources of water for the lake are Göksu Spring, Aksu Stream, Kizılli Stream, Balliktas Stream, Köy Stream, rainwater, snow, and runoff water from the nearby villages (Becer and Ikiz, 2009., Becer and Kilic, 2019). Samples were collected from seven sampling sites bimonthly from January 2022 to December 2022 (Figure 1). Several criteria guided the selection of sampling points, including the inflow and outflow areas of the dam lake, the geographical proximity of industrial activities (especially regarding effluent), nearby tourism, agricultural, and aquaculture operations, the lake's drainage patterns, and how easily the locations could be accessed (Table 1).

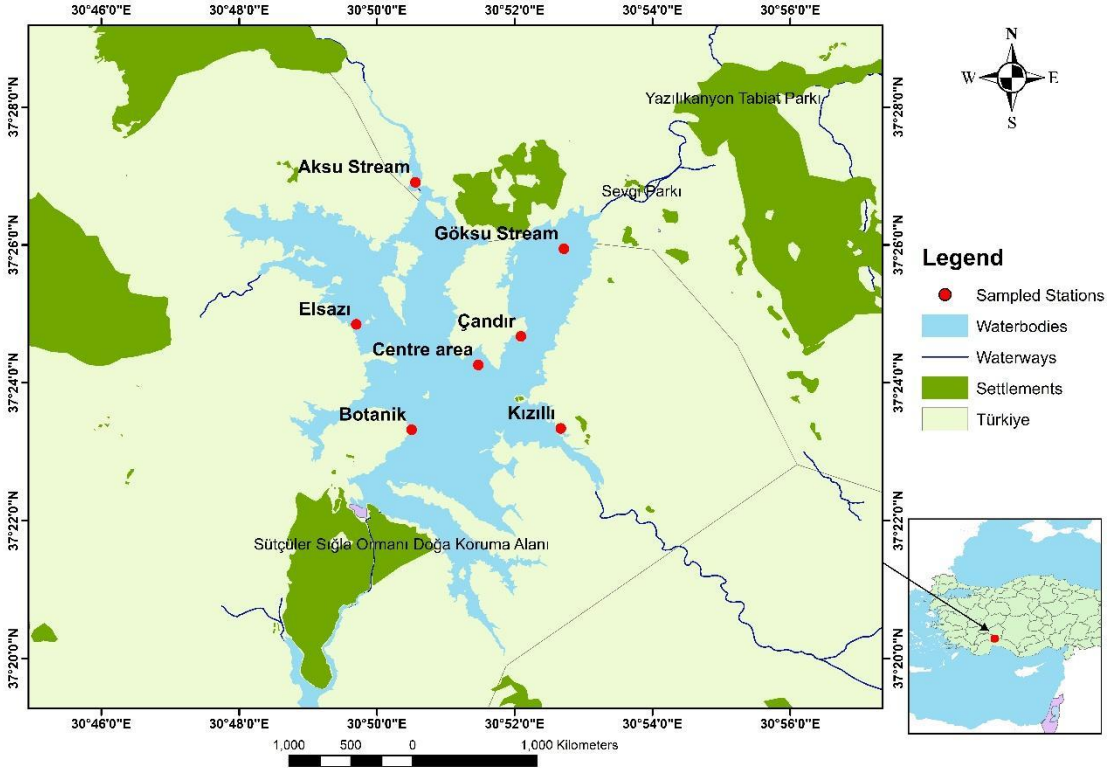


Figure 1. Karacaören I Dam Lake and sampling stations.

Table 1. Geographic coordinates of sampling stations.

Sampling stations	Coordinates	
1. Botanik/Saklı Lake Houses	N 37°23'19.11012"	E 30°50'30.3072"
2. (Kızıllı)	N 37°23'20.34564"	E 30°52'40.33812"
3. (Çandır)	N 37°24'40.37976"	E 30°52'5.57652"
4. (Göksu Stream)	N 37°25'56.63568"	E 30°52'43.04352"
5. (Centre area)	N 37°24'15.54876"	E 30°51'28.4868"
6. (Aksu Stream)	N 37°26'54.51648"	E 30°50'33.7308
7. (Elsazı)	N 37°24'50.91264"	E 30°49'42.06936"

2.2. Macroinvertebrates Sampling, Storage, Preservation and Identification Methods

Macroinvertebrate sampling at each station involved the use of a standardized 50 × 30 cm kick-net with a 500 µm mesh size. Samples were obtained from all available microhabitats within a 100-meter radius, encompassing substrates such as silt, gravel, sediment, grasses, and woody debris. In rocky areas, attached macroinvertebrates, including pupae, were manually dislodged and collected using the kick-net in the littoral region by researchers wearing waders. Ekman grab was used to collect macroinvertebrates from muds. Samples were preserved in 70% ethanol in labelled Ziplock bags and transported to the Akdeniz University Faculty of Fisheries laboratory for taxonomic processing, involving sorting and identification to the family level via stereomicroscopy and taxonomic keys (Plafkin et al., 1989).

2.3. Biological Water Quality Determination Methods

Family biotic index (FBI), Biological Monitoring Working Party Score System (BMWP) and average score per taxon (ASPT) was used to determine Biological Water Quality.

The FBI index takes into consideration the number of individuals in families. (Bode et al., 1991). The family biotic index is calculated using the following formula:

$$FBI = \sum \frac{X_i T_i}{n}$$

Where: Xi = number of taxa, ti = tolerance value of taxon, n = number of organisms in the samples collected.

The BMWP score system ranks families of benthic macroinvertebrates from 1 to 10 based on how sensitive they are to pollution, where higher scores indicate greater sensitivity (Burdon et al., 2020). The individual scores assigned to each family are summed together, and an overall BMWP score is obtained, indicating the water body's biological condition (Walley & Fontama, 1998).

The ASPT can be calculated as follows:

$$ASPT = \frac{BMWP\ Index}{\sum Taxa}$$

The ASPT index is well-suited for assessing the impact of organic pollution (Armitage et al., 1983)

3. RESULTS and DISCUSSION

3.1. Macroinvertebrates abundance and distribution according to sampling stations

In this study conducted between January 2022 and December 2022, Karacacaören I Dam Lake, eight hundred forty-one (841) individual macroinvertebrates belonging to 24 families and 11 orders, were sampled from Karacacaören I Dam Lake during this study (Table 2). The identified families in this study were Gammaridae, Palaemonidae, Potamidae, Erpobdellidae, Lumbriculidae, Hydrophilidae, Heteroceridae, Carabidae, Chironomidae, Ceratopogonidae, Baetidae, Caenidae, Notonectidae, Corixidae, Libellulidae, Calopterygidae, Coenagrionidae, Aeshnidae, Gomphidae, Macromiidae, Hydropsychidae, Planorbidae, Physidae, and Lymnaeidae. The number of families recorded in this study is higher than the 6 families reported by Karaşahin and Yıldırım (2001) in Karacacaören-I Dam Lake but less than the numbers of taxa reported by Zeybek et al. (2011), in both Karacacaören I and Karacacaören II dam lakes. In this study, no family belonging to the Bivalvia class was found. Altough, Karaşahin and Yıldırım (2001) and Zeybek et al. (2011) reported species of the Bivalvia family.

Table 2. Frequencies of invertebrates according to stations.

Macroinvertebrates		**Sampling Stations**							**Total**
Order	Family	St1	St2	St3	St4	St5	St6	St7	N (%)
Amphipoda	Gammaridae	-	-	1	1	8	-	2	12(1.43)
Decapoda	Palaemonidae	24	25	46	33	39	4	28	199(23.66)
	Potamidae	-	-	4	1	-	-	-	5(0.59)
Arhynchobdellida	Erpobdellidae	-	-	-	3	-	-	-	3(0.36)
Lumbriculida	Lumbriculidae	-	-	-	2	-	-	-	2(0.24)
	Hydrophilidae	-	9	2	3	11	-	3	28(3.33)
Coleoptera	Heteroceridae	-	-	2	-	-	-	-	2(0.24)
	Carabidae	-	-	-	-	1	-	-	1(0.12)
Diptera	Chironomidae	19	61	11	18	65	38	15	227(26.99)
	Ceratopogonidae	-	-	-	-	-	5	-	5(0.59)
Ephemeroptera	Baetidae	-	-	-	1	-	-	-	1(0.12)
	Caenidae	-	-	-	4	-	-	-	4(0.48)
Hemiptera	Notonectidae	3	2	2	65	1	1	48	122(14.51)
	Corixidae	-	6	17	62	1	12	7	105(12.49)
	Libellulidae	6	2	5	5	-	9	1	28(3.33)
	Calopterygidae	-	1	-	1	-	-	-	2(0.24)
Odonata	Coenagrionidae	-	1	8	2	2	15	5	33(3.92)
	Aeshnidae	-	-	6	5	1	4	-	16(1.90)
	Gomphidae	-	-	1	-	-	-	-	1(0.12)
	Macromiidae	-	-	-	-	-	1	-	1(0.12)
Trichoptera	Hydropsychidae	-	-	-	2	-	-	-	2(0.24)
	Planorbidae	-	2	-	-	-	-	-	2(0.24)
Gastropoda	Physidae	-	2	3	4	-	5	-	14(1.66)
	Lymnaeidae	-	3	20	-	3	-	-	26(3.09)
Total (%) = 11	24	52	114	128	212	132	94	109	841(100)

The four most abundant and dominant macroinvertebrate families were Chironomidae, Palaemonidae, Notonectidae, and Corixidae. These four families comprised 77.65 % of this

study's total sampled macroinvertebrate families (Figure 2). These four families were distributed throughout this study and in all stations. The results also showed that station 4 has the highest number of sampled macroinvertebrates, followed by station 3 while the least number of macroinvertebrates was obtained in station 1 (Table 2).

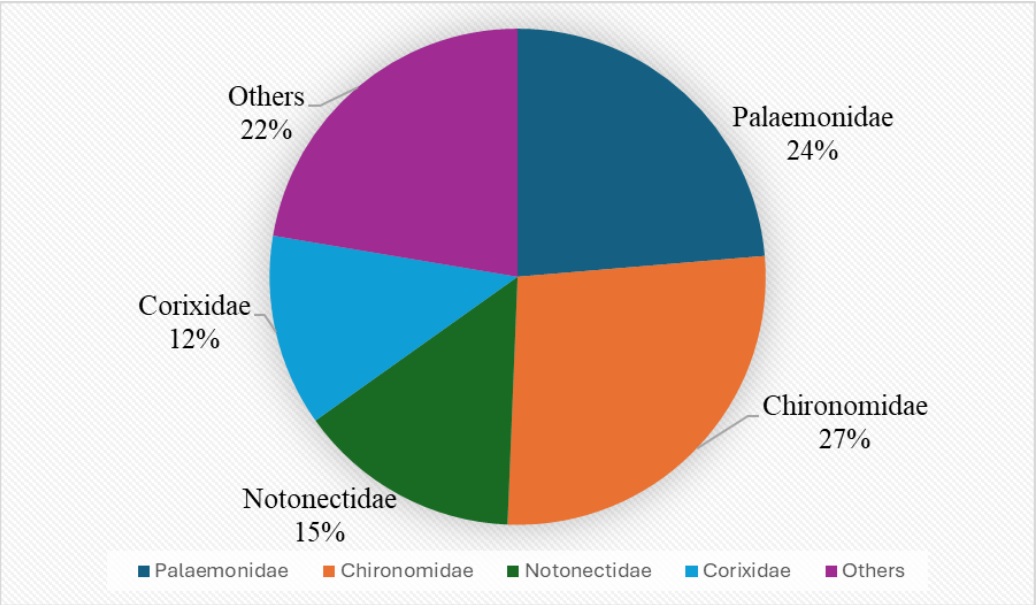


Figure 2. Percentage distribution of macroinvertebrates.

Chironomidae species can inhabit a wide range of environments, including muddy, rocky, or plant-littered sediments. The *Chironomus* sp. is found in diverse aquatic habitats, from small trickles to large rivers, temporary pools to deep lakes, and in both soft sediment and on rocky surfaces. Furthermore, several *Chironomus* sp. can withstand low levels of dissolved oxygen. (Chazanah et al., 2020). According to Muntalif et al. (2008), *Chironomous* sp. can live in locations with high organic pollution. In the stations where Chironomidae species were the dominant families, a high level of organic waste was observed, especially at station 6, where domestic waste and septic waste from Isparta and the environment entered Karacaören I Dam Lake through the Aksu stream.

The high abundance of the Palaemonidae family can be explained by the fact that they are free swimmers. During the winter, the water inflow into the Dam Lake increases, providing them a better opportunity to move freely. Studies have shown that the Palaemonidae family tends to be more abundant during winter and reduces as water temperatures increase in the summer (Rosa et al., 2015; Laino et al., 2020). Anthropogenic activities modify communities, and the mechanisms may vary from loss of sensitive species or traits to increases in non-native species, among others (Michaud et al., 2022).

Corixidae prefer a lentic aquatic system for their habitat (Priawandiputra et al., 2018). The broad distribution of Corixidae across oligotrophic, mesotrophic, and eutrophic lake ecosystems is well-documented. The consistent presence of high organic matter levels in the study sites suggests an enhanced availability of food resources for this herbivorous insect group (Priawandiputra et al., 2018). The herbivore nature of Corixidae could be the reason behind the high abundance in station 4 (Göksu area) because it is rich in organic materials like dead plants and has a high abundance of aquatic plants.

Adult backswimmers (Notonectidae) of many species reproduce in the shallow edges of lakes and permanent ponds, while others breed in the pools found within streams. Additionally, some Notonectidae species are temporary inhabitants of seasonal ponds. The ability of *Notonecta* sp to inhabit deeper waters and remain submerged for extended times is attributed to their ventral channels, which function to retain a plastron, enabling respiration underwater. (Hilsenhoff, 2001). *Notonecta* adults and nymphs typically hang from the surface film, which enables them

to maintain neutral buoyancy and remain planktonic (Hilsenhoff, 2001). Adults and nymphs of *Notonecta* are active predators that pursue or ambush other invertebrates or small vertebrates. Therefore, they tend to be more in areas with a high abundance of other macroinvertebrates (Polhemus, 2009). Most species live in the quiet parts of streams or lentic habitats (Polhemus, 2009).

The presence of large numbers of aquatic bugs, such as Notonectidae and Corixidae, are sometimes indicators of water pollution (Thorp & Rogers, 2011). Although their tolerance to toxins might not be higher than other insects, aquatic bugs largely avoid the challenges posed by polluted, low-oxygen environments because, unlike many other aquatic insects, they obtain their oxygen directly from the air (Thorp & Rogers, 2011).

In addition to physicochemical measurements, using benthic macroinvertebrates as bio-indicators in determining the water quality of aquatic bodies such as lakes, dams, rivers allow us to get more accurate results. Benthic macroinvertebrates are often used as pollution bioindicators to examine the impacts of anthropogenic activities such as canalization, industrial effluents, agricultural waste, and other organic waste, such as domestic waste, on the environment (Khatri et al., 2020; Parikh et al., 2021; Adesakin et al., 2023). Some bottom-dwelling macroinvertebrates (benthos) either live their entire lives in the water or emerge to become terrestrial insects (Khatri et al., 2020; Adesakin et al., 2023). The fact that macroinvertebrates exhibit a range of sensitivities to contamination, it shapes the structure of their communities. As a result, these organisms are present in all aquatic environments (Khatri et al., 2020; Adesakin et al., 2023). The localized life habits of many macroinvertebrates and the straightforward methods for collecting them make them a quick and budget-friendly option for biomonitoring (Parikh et al., 2021). Assessing the ecological quality of water bodies can be realistically and practically achieved by analyzing the abundance, diversity, and distribution of benthic macroinvertebrates.

3.2. Biological Water Quality Determination

The results of the BMWP biotic index showed that the water quality of stations 2, 3, 4, 5, and 6 were moderately polluted by organic substances (III) class. In contrast, stations 1 and 7 (IV) had poor water quality due to pollution from organic substances (Figure 3). ASPT results showed that stations 1, 3, 4, 5, 6, and 7 possessed good water quality (class II) while station 2 possessed moderate level water quality (class III) (Figure 4). On the other hand, the FBI results showed station 1 and 5 possessed excellent water quality (not contaminated by organic waste) (class I), station 7 possessed a very good water quality (class I - II), and station 6 possessed relatively poor water quality (class III-IV). In contrast, stations 2, 3, and 4 possessed poor water quality (class IV) (Figure 5).

Three biotic indices [monitoring working party (BMWP); average score per taxon (ASPT) and family biotic index (FBI)] were calculated and employed to determine the level of organic pollution of Karacaören I Dam Lake. These indexes, BMWP and ASPT, use the pollution sensitivity of invertebrate families to determine water quality.

The BMWP index showed that all the stations in this study were polluted; stations 2, 3, 4, 5, and 6 fell under class III, while station 1 and station 7 fell under class IV. The ASPT index results analysis showed that the water quality in stations 1, 3, 4, 5, 6, and 7 fell under class II while station 2 was in class III. The ASPT index results obtained for station 2 and the BMWP index results agreed. On the other hand, the FBI results indicated that station I and station 5 water was excellent (class I), stations 2, 3, 4, and 6 were relatively poor (class IV), while station 7 water was in good condition (class II). Research across various lakes and rivers has shown a direct relationship between water quality and the diversity of benthic macroinvertebrates: higher water quality corresponds to greater diversity, while increased pollution leads to a decline in diversity (Kalyoncu & Zeybek, 2011; Baytaşoğlu & Gözler, 2021). There were discrepancies between the biotic indices in this study. Other researchers have also observed discrepancies between biotic indices (Ertaş et al., 2022; Özbek et al., 2023).

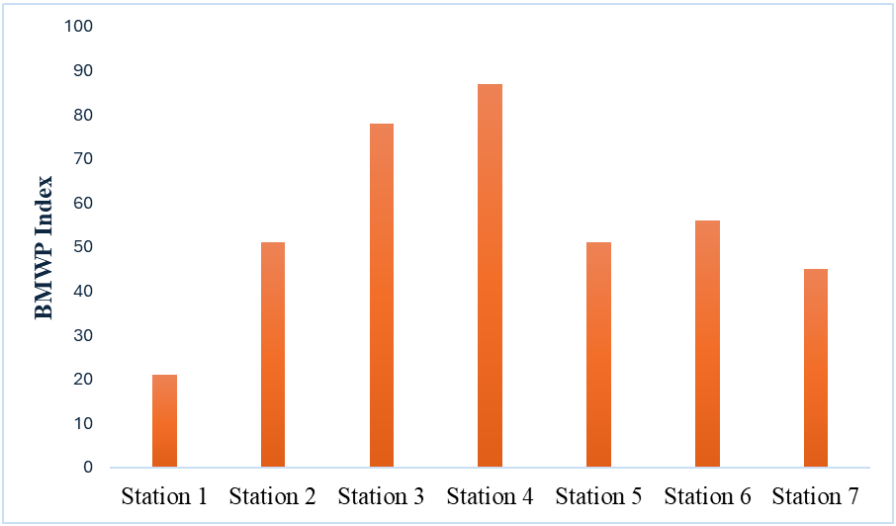


Figure 3. BMWP index according to sampling stations. *BMWP: > 150 Excellent; 101 – 150 good; 51 – 100 moderately; 16 – 50 poor; and 0 – 15 very poor*.

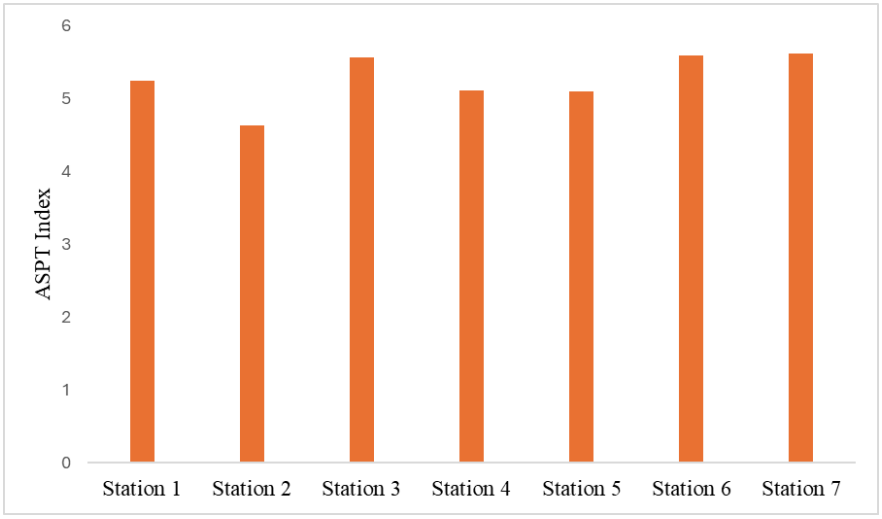


Figure 4. ASPT index according to sampling stations. *ASPT: > 6 Excellent; 5 – 6 good; 4 – 5 moderately; and < 4 very poor*.

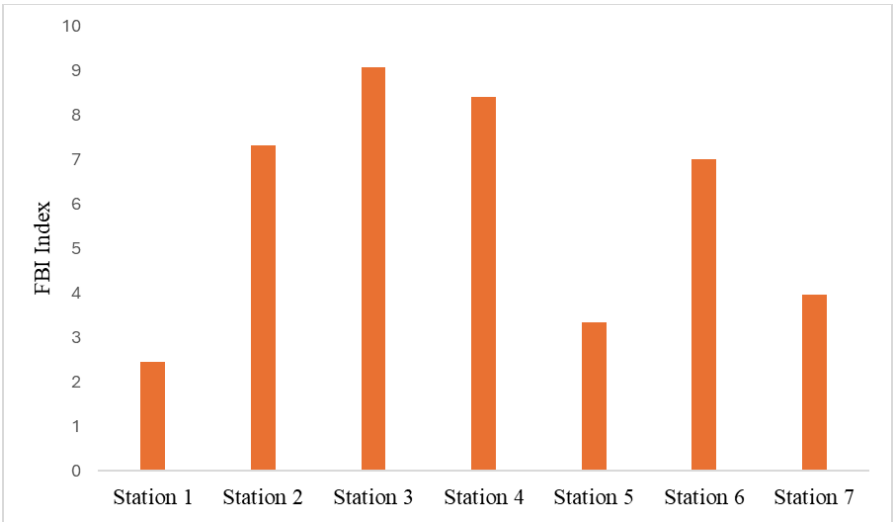


Figure 5. FBI index according to sampling stations. *FBI: 0.00-3.75 Excellent; 3.76-4.25 Very good; 4.26-5.00 Good; 5.01-5.75 Fair; 5.76-6.50 relatively poor; 6.51-7.25 Poor; and 7.26-10.00 Very poor*.

CONCLUSION

In this research, the results of biotic indices show that the water quality of Karacaören I Dam Lake was negatively impacted by human activities. Therefore, realizing the planned use of Karacaören I Dam Lake water as a potential source of drinking water is related to adopting protection measures to prevent further deterioration of the water quality, in addition, it is pertinent to educate the people on the danger of irresponsible waste disposal, use of chemical fertilizers and other human activities that can lead to deterioration of water bodies. Finally, policies that will enhance the quality of the water of the dam lake should be encouraged.

ACKNOWLEDGEMENTS

We are grateful to the management and staff of the Akdeniz University Scientific Research Projects for financially supporting this research. Finally, we do not forget to thank Gamze Kızılcalıoğlu for always assisting during field and laboratory works.

AUTHOR CONTRIBUTIONS

Edafe ODIOKO carried out the conceptualisation, methodology, fieldwork, laboratory works, data analysis and interpretation, and writing/original draft. Zehra Arzu BECER supervised, reviewed, edited and proofread the manuscript.

FUNDING

The Akdeniz University Scientific Research Projects Coordination Unit (BAP) supported the work with approval code FDK-2021-5779. This support is part of the assistance granted for PhD research.

No funding for article publication is available.

DECLARATIONS

The authors declare that they have read, understood, and complied with the ethical author responsibilities detailed in the Instructions for Authors, as applicable.

CONFLICT OF INTEREST

The authors have no conflict of interest concerning the study and its publication.

DATA AVAILABILITY

The data used in this study can be obtained from the relevant author upon reasonable request.

REFERENCES

Adesakin, T.A., Erhomosele, E.I., Ogunrinola, O.F., Oloyede, O.O., Adedeji, A.A., Odufuwa, P.T., Aimienoho, A., Aduwo, A. I., & Adewumi, E.A. (2023). Using benthic macroinvertebrates as bioindicators to evaluate the impact of anthropogenic stressors on water quality and sediment properties of a West African lagoon. *Heliyon*, 9: e19508. https://doi.org/10.1016/j.heliyon.2023.e19508

Albayrak, E., & Özuluğ, O. (2016). Benthıc Macroınvertebrates of Lake Danamandıra (Sılıvrı-Istanbul). *Aquatic Sciences and Engineering*, *3*(1): 51-58. https://doi.org/10.18864/TJAS201606

Armitage, P. D., Moss D., Wright, J. F. & Furse, M. T. (1983). The performance of a new biological water quality score system based on macroinvertebrates over a wide range of unpolluted running water sites. *Water Research*, 17(3): 333-347. https://doi.org/10.1016/0043-1354(83)90188-4

Baytaşoğlu, H., & Gözler, A.M. (2021). Evaluation of water quality of Çoruh River Basin (Turkey) using some biotic indices. *Ege Journal of Fisheries and Aquatic Sciences*, *38*(4): 399-409. https://doi.org/10.12714/egejfas.38.4.01

Becer, Z. A., & Ikiz, R. (2008). Growth, Mortality and Stock Analysis of the pikeperch, *Sander lucioperca* (L., 1758) population of Karacaören I Dam Lake. *Journal of Fisheries Sciences*, 2(2): 134-145. https://doi.org/10.3153/jfscom.2008015

Becer, Z. A., & Ikiz, R. (2009). Mortality ratio and stock analysis of Vimba (*Vimba vimba tenella* (Nordmann,1840) population in Karacaören I Dam Lake (Burdur-Turkey). *Journal of Applied Biological Sciences, 3*: 143-147.

Becer, Z.A., & Karabacak, G.S. (2011). Changes in the Population Structure of Pikeperch (*Sander lucioperca* (Linnaeus, 1758)) Karacaören–I Dam Lake, Turkey. *Journal of Animal and Veterinary Advances*, 10 (2): 224-228.

Becer Z.A., Apaydin Yagci, M., Yagci, A., & Alp, A. (2018). Diet of Sand Smelt, *Atherina boyeri* (Risso, 1810) During the Reproductive Period in Karacaören Dam

Lake (TURKEY). *Fresenius Environmental Bulletin*. 27 (7): 5173-5178.

Becer Z. A., & Kilic S. (2019). Effect on Lake Fishery and Some Biological Characters of the Sand Smelt, (Atherina boyeri Risso, 1810) Introduced to Karacaören I Dam Lake (Turkey), *Fresenius Environmental Bulletin*. 27, 9392-9398

Bettinetti, R., Ponti, B., Marziali, L. & Rossaro, B. (2012). Biomonitoring of lake sediments using benthic macroinvertebrates. *Trends in Analytical Chemistry*, *36*: 92-102. https://doi.org/10.1016/j.trac.2011.12.008

Bode, R.W., Novak, M.A., & Abele, L.E. (1991). *Methods for rapid biological assessment of stream* (pp. 57). New York State Department of Environmental Conservation, Albany, New York.

Burdon, F. J., Ramberg, E., Sargac, J., Forio, M. A. E., de Saeyer, N., Mutinova, P. T., Moe, T. F., Pavelescu, M. O., Dinu, V., Cazacu, C., Witing, F., Kupilas, B., Grandin, U., Volk, M., Rîşnoveanu, G., Goethals, P., Friberg, N., Johnson, R. K., & McKie, B. G. (2020). Assessing the Benefits of Forested Riparian Zones: A Qualitative Index of Riparian Integrity Is Positively Associated with Ecological Status in European Streams. *Water*, *12*(4), 1178. https://doi.org/10.3390/w12041178

Callisto, M., Moreno, P., & Barbosa, F. A. R. (2001). Habitat diversity and benthic functional trophic groups at Serra do Cipo, southeast Brazil. *Revista Brasileira de Biologia*, 61: 259–266. http://dx.doi.org/10.1590/S0034-71082001000200008

Chazanah, N., Muntalif, B. S., Rahmayani, R. A. & Sudjono, P. (2020). Macrozoobentos distribution as a bioindicator of water quality in the upstream of the Citarum river. *Journal of Ecological Engineering*, *21*(3): 10-17. https://doi.org/10.12911/22998993/116335

DSİ. (2015). Karacaören 2. Barajı İsale Hattı Çalışmalar Devam Ediyor. Devlet Su İşleri Genel Müdürlüğü, 13. Bölge Müdürlüğü Antalya. https://bolge13.dsi.gov.tr/haberler/2015/04/09/antalya-nin-i-%C3%A7mesuyu-sorununu-ortadan-kaldiriyoruz [accessed on 17.11.2021]

Dzhurtubaev, Y., Zamorov, V., Dzhurtubaev, M., Shadrin, N., & Yakovenko, V. (2021). Long-term dynamics of the macrozoobenthos in the Kytai Lake (Danube River, Odessa region, Ukraine). *Plankton and Benthos Research*, *16*(1): 11-23. https://doi.org/10.3800/pbr.16.11

Ertaş, A., Yorulmaz, B., & Sukatar, A. (2022). Comparative analysis of biotic indices for assessment of water quality of Balaban Stream in West Anatolia, Turkey. *Biologia*, *77*: 721–730. https://doi.org/10.1007/s11756-021-00992-7

Ganguly, I., Patnaik, L., & Nayak, S. (2018). Macroinvertebrates and its impact in assessing water quality of riverine system: a case study of Mahanadi River, Cuttack, India. *Journal of Applied and Natural Science*, *10*(3), 958 - 96. https://doi.org/10.31018/jans.v10i3.1817

Gülle, I. (2005). Karacaören I Baraj Gölü (Burdur) planktonunun taksonomik ve ekolojik olarak incelenmesi. Doktora Tezi, Süleyman Demirel Üniversitesi, Fen Bilimleri Enstitüsü, Isparta, 201s.

Hilsenhoff, W. L. (1987) An Improved Biotic Index of Organic Stream Pollution. *Great Lakes Entomologist*, *20*: 31-39.

Kaban, S., Armanto, M. E., Ridho, M. R. & Hariani, P. L. (2018). Rapid Assessment of Water Quality in Teluk Lake by Using Macroinvertebrates (A Family Level Biotic Index). The 1st Sriwijaya International Conference on Environmental Issues 2018 (1st SRICOENV 2018), 1-9 https://doi.org/10.1051/e3sconf/20186804006

Kalyoncu, H., & Zeybek, M. (2011). An application of different biotic and diversity indices for assessing water quality: A case study in the Rivers Çukurca and Isparta (Turkey). *African Journal of Agricultural Research*, *6* (1), 19-27. https://doi.org/10.5897/AJAR09

Karaşahin, B., & Yildirim, M. Z. (2001). Karacaören 1 Baraj Gölü' nün bentik faunası üzerine bir çalışma. *Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 5*(2): 214 - 231.

Kazancı N., Öz, B., Dügel, M., Türkmen, G. & Ertunç, Ö. 2010. First faunistic and ecological survey of ınterstitial fauna of streams in Turkey, Verhandlungen des

Internationalen Verein Limnologie, 30 (9): 1466. https://doi.org/10.1080/03680770.2009.11902355

Khatri, N., Tyagi, S., Rawtani, D., & Tharmavaram, M. (2020). Assessment of river water quality through application of indices: a case study River Sabarmati, Gujarat India. *Sustain Water Resource Management*, 6(6): 101. https://doi.org/10.1007/s40899-020-00459-8

Kılçık, F. (2020). Demre Çayı'nın Fizikokimyasal ve Biyolojikyönden İzlenmesi. Doktora Tezi, Süleyman Demirel Üniversitesi, Isparta, 182 s.

Kızılkaya, S. (2022). Dipsiz – Çine Çayı'nın Makrozoobentik Organizmalara Göre ve Fizikokimyasal Yöntemlerle Su Kalitesi Tayini. Yüksek Lisans Tezi, Muğla Sıtkı Koçman Üniversitesi, Muğla, 91 s.

Kökçü, C. A. (2016). Sapanca Gölü Ekolojik Kalitesinin Makroomurgasızlara Dayalı Olarak Su Çerçeve Direktifi (SÇD) Doğrultusunda Değerlendirilmesi. Doktora tezi, Eskişehir Osmangazi Üniversitesi, Eskişehir, 197 s.

Laino, P. S., Musiello-Fernandes, J., & Braga, A. B. (2020). Population structure of the shrimp Palaemon pandaliformis (Stimpson, 1871) (Caridea: Palaemonidae) in the river Rio Itapemirim, in Southeastern Brazil. *Biota Neotropica, 20*(4): e20201020. https://doi.org/10.1590/1676-0611-BN-2020-1020

Metcalfe, J.L. (1989). Biological Water Quality Assessment of Running Waters Based on Macroinvertebrate Communities: History and Present Status in Europe. *Environmental Pollution, 60*:101-139

Michaud, K. M., Reed, D. C., & Miller, R. J. (2022). The Blob marine heatwave transforms California kelp forest ecosystems. *Communications Biology, 5*, 1143. https://doi.org/10.1038/s42003-022-04107-z

Muntalif, B. S., Ratnawati, K., & dan Bahri, S. (2008). Bioassessment Menggunakan Makroinvertebrata Bentik Untuk Penentuan Kualitas Air Sungai Citarum Hulu. *Jurnal Purifikasi, 9*(1): 49 -60.

Ochieng, H., Odong, R., & James Okot-Okumu, J. (2020). Comparison of temperate and tropical versions of Biological Monitoring Working Party (BMWP) index for assessing water quality of River Aturukuku in Eastern Uganda. *Global Ecology and Conservation*, 23. https://doi.org/10.1016/j.gecco.2020.e01183

Özbek, M., Aygen, C., Taşdemir, A., Yildiz, S., Topkara, E. T., & Çil, E. A. (2023). Determination of the ecological status of an Aegean river (Türkiye) using benthic macroinvertebrates as an indicator of water quality. *Environmental Monitoring and Assessment, 195*(10): 1231. https://doi.org/10.1007/s10661-023-11834-1

Parikh, G., Rawtani, D., & Khatri, N. (2021). Insects as an indicator for environmental pollution. *Environmental Claims Journal, 33*(2): 161-181, https://doi.org/10.1080/10406026.2020.1780698

Plafkin, J.L., Barbour, M.T., Porter, K.D., Gross, S.K., & Hughes, R.M. (1989). Rapid Bioassessment Protocols for use in Streams and Rivers: *Benthic Macroinvertebrates and Fish*. U.S. Environmental Protection Agency. EPA 440/4-89/001. 8 chapters, Appendices A-D.

Polhemus, J. T. (2009). Hemiptera (True Bugs). *Encyclopedia of Inland Waters*, 323-334. https://doi.org/10.1016/B978-012370626-3.00175-7

Priawandiputra, W., Zakaria, F. R. N., & Prawasti, T. S. (2018). Aquatic Insect Community as Indicator of Water Quality Assessment in Situ Gede System, Bogor, Indonesia. *IOP Conf. Series: Earth and Environmental Science*, 197: 012016. https://doi.org/10.1088/1755-1315/197/1/012016

Rosa, L. C., Passos, A. C., & Corrêa, M. F. M. (2015). Aspectos populacionais e reprodutivos de *Palaemon pandaliformis* (Crustacea: Palaemonidae) em uma marisma subtropical no Sul do Brasil. São Paulo. *Boletim do Instituto de Pesca, 41*(4): 849-857

Segnini, S. (2003). El uso de los macroinvertebrados bentónicos como indicadores de la condición ecológica de los cuerpos de agua corriente. *Ecotropicos*, 16 (2): 45-63

Šidagytė, E., Višinskienė, G., & Arbačiauska, K. (2013). Macroinvertebrate metrics and their integration for assessing the ecological status and biocontamination of Lithuanian lakes. *Limnologica* 43: 308-318. http://dx.doi.org/10.1016/j.limno.2013.01.003

Spyra, A., Kubicka, J., & Strzelec, M. (2017). The use of biological indices for the assessment of the river quality (Ruda river, Poland). *Ecological Chemistry and Engineering*, 24: 285-298. https://doi.org/10.1515/eces-2017-0020

Süel, H., Oğurlu, İ. & Ertuğrul, E. T. (2018). Bird Fauna of Karacaören I Dam Lake, Isparta-Turkey. *The Journal of Graduate School of Natural and Applied Sciences of Mehmet Akif Ersoy University*, 9(1): 22-28. https://doi.org/10.29048/makufebed.320113

Teksoy, A., Katip, A. & Erol Nalbur, B. (2019). Karsak deresi'nde su kalitesinin izlenmesi ve gemlik körfezi'ne etkisinin değerlendirilmesi. *Uludağ University Journal of the Faculty of Engineering*, 24: 1. https://doi.org/10.17482/uumfd.463430

Thorp, J. H., & Rogers, D. C. (2011). True Bugs: Insect Order Hemiptera. In: Thorp, J. H. and Rogers, D.C. (Ed), Field Guide to Freshwater Invertebrates of North America. *Academic Press*, pp. 205-212. https://doi.org/10.1016/B978-0-12-381426-5.00023-5

Walley, W. J., & Fontama, V. N. (1998). Neural network predictors of average score per taxon and number of families at unpolluted river sites in Great Britain. *Water Research*, *32*: 613–622. https://doi.org/10.1016/S0043-1354(97)00274-1

Yorulmaz, B., & Ertaş, A. (2021). Water quality assessment of Selendi Stream and comparative performance of the indices based on benthic macroinvertebrates and physicochemical parameters. *Biologia*, 76: 2599-2607.

Zeybek, M., Özgül S., Karakaş B., & Taş A.İ. (2011). Karacaören Baraj Gölleri nin Giriş ve Çıkış Sularında Su Kalitesi Değişiminin Biyolojik ve Fizikokimyasal Parametrelere Göre Belirlenmesi. X. Ulusal Ekoloji ve Çevre Kongresi, 1, Çanakkale, Turkey, 4 - 07 October 2011.

Zeybek, M. (2012). Kovada Kanalı Ve Bağlantılı Olduğu Göl Sularında Su Niteliğinin Belirlenmesi. Doktora Tezi, Süleyman Demirel Üniversitesi, Isparta, 169 s.

Zeybek, M. (2017). Macroinvertebrate-based biotic indices for evaluating the water quality of Kargı Stream (Antalya, Turkey). *Turkish Journal of Zoology*, 41(3): 476-486. https://doi.org/10.3906/zoo-1602-10

Zeybek, M., Kalyoncu, H., Karakaş, B., & Özgül, S. (2014). The use of BMWP and ASPT indices for evaluation of water quality according to macroinvertebrates in Değirmendere Stream (Isparta, Turkey). *Turkish Journal of Zoology*, *38*(5): 11. https://doi.org/10.3906/zoo-1310-9