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Spatiotemporal Variations in Macrozoobenthic Communities at the Mouth of the Mezitli Stream, Mersin Bay (Northeastern Mediterranean)

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Research Article

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Abstract

This study evaluated the ecological status of macrozoobenthic communities at the mouth of Mezitli Stream, Mersin Bay, under spatiotemporal variability and pollution pressures. Sediment samples were collected from six stations during dry and wet seasons; Shannon-Weaver Diversity Index, Margalef's Species Richness Index, and AZTI's Marine Biotic Index (AMBI) were used to assess ecosystem health. In addition, the oxidation-reduction potential (ORP) of the sediment was measured as a supportive indicator of environmental conditions. During the dry season, low Shannon and Margalef values, together with low ORP levels, were observed, especially at Stations 5 and 6, due to possible oxygen deficiency and degraded benthic structure. These stream-influenced stations stood out as the most degraded areas with high AMBI scores, dominance of tolerant species (*Nereis* sp., *Corbula gibba*), and low dissolved oxygen levels. During the wet season, increased freshwater inflow and improved oxygen resulted in richer and more balanced communities (e.g. *Alvania discors*, *Tellina* sp. and *Mangelia* sp.). Despite these conditions, Stations 5 and 6 exhibited lower Shannon, Margalef, AMBI scores and ORP levels. The findings reveal that seasonal changes in organic load and oxygen levels are the main factors determining the structure of the benthic ecosystem in the Mezitli Stream mouth area.

Keywords: *Macrozoobenthos, Shannon-Weaver index, Margalef's richness index, AZTI's marine biotic index, Mezitli Stream, Türkiye.*

Introduction

The Mediterranean is a semi-enclosed marine ecosystem characterized by high biodiversity and ecological complexity (Turan et al., 2025). Due to its unique ecological characteristics and proximity

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to densely populated coastlines, it is highly vulnerable to pollution, habitat degradation and climate-induced environmental changes (Koyuncu and Ayas, 2024; Turan et al., 2024). Stream ecosystems provide suitable habitats for various biological communities due to their high nutrient levels (Dudgeon et al., 2006). However, nutrients, sediments, and pollutants carried by rivers emptying into the Mediterranean Basin are degrading water quality and threatening benthic habitats due to increasing anthropogenic pressures (İlhan et al., 2024). Stress factors such as industrial discharge, agricultural runoff, and urbanization increase this degradation (Eken and Akman, 2018). Therefore, biological monitoring is of great importance for monitoring ecosystem health.

Macrozoobenthic organisms, defined as benthic invertebrates that exhibit a high degree of sensitivity to environmental changes, function as pivotal bioindicators within the framework of aquatic monitoring programs (Douterelo et al., 2004). The composition of the species, the abundance and distribution of these organisms offer valuable information about the ecological status of water systems. Numerous biotic indices such as the Shannon-Weaver Diversity Index (Shannon and Weaver, 1949), Margalef's Species Richness (Margalef, 1958), and AMBI (AZTI's Marine Biotic Index) (Borja et al., 2019) are widely used for this purpose. The evaluation of ecosystem quality over time is facilitated by these indices, which employ diversity and pollution tolerance as their measuring sticks. These organisms, functioning as decomposers and secondary consumers, exhibit heightened sensitivity to factors such as oxygen availability, organic matter accumulation, and sediment structure, thereby serving as ideal indicators of ecological disturbances (Wallace and Webster, 1996). The structure of macrozoobenthic communities is determined by abiotic (e.g. water temperature, pH, dissolved oxygen, and substrate properties) and biotic (interactions with other organisms and food chain relationships) characteristics of the habitat they are found in. These environmental factors shape the distribution and community composition of macrozoobenthic organisms, providing important information about the ecological status and quality of the water body (Poff et al., 1997).

Seasonal hydrological shifts have been demonstrated to exert a substantial influence on the distribution of macrozoobenthic organisms. During the spring and summer months, decreased precipitation and nutrient input can potentially restrict oxygen availability, thereby affecting biological processes such as reproduction and development (Ge et al., 2025). Conversely, during the autumn and winter months, elevated water volumes, concomitant with augmented organic matter influx, have been observed to promote heightened species richness and abundance. Furthermore, variations in sediment composition and redox conditions along depth gradients play a decisive role in shaping community structure, often favoring greater diversity in deeper, oxygen-rich environments (Vinson and Hawkins, 1998).

Starting from the Taurus Mountains and flowing into the Mediterranean, Mezitli Stream, which is characterized by a hydrologically complex transition ecosystem in terms of being exposed to anthropogenic pressures such as agricultural runoff, industrial discharge and urban pollution, lacks a comprehensive study evaluating the benthic fauna and ecosystem health at its mouth. Therefore, this study aimed to present an up-to-date inventory of macrozoobenthic species at the mouth of Mezitli Stream and to obtain basic ecological data to support biomonitoring and guide conservation strategies for benthic habitats by evaluating depth-related and seasonal changes in community structure, ecosystem health and pollution status.

Material and Methods

Study area

Sampling was conducted at the point where Mezitli Stream enters the Mediterranean (Figure 1) during both dry and wet seasons. The study was carried out at six stations, whose coordinates and depths are provided in Table 1.

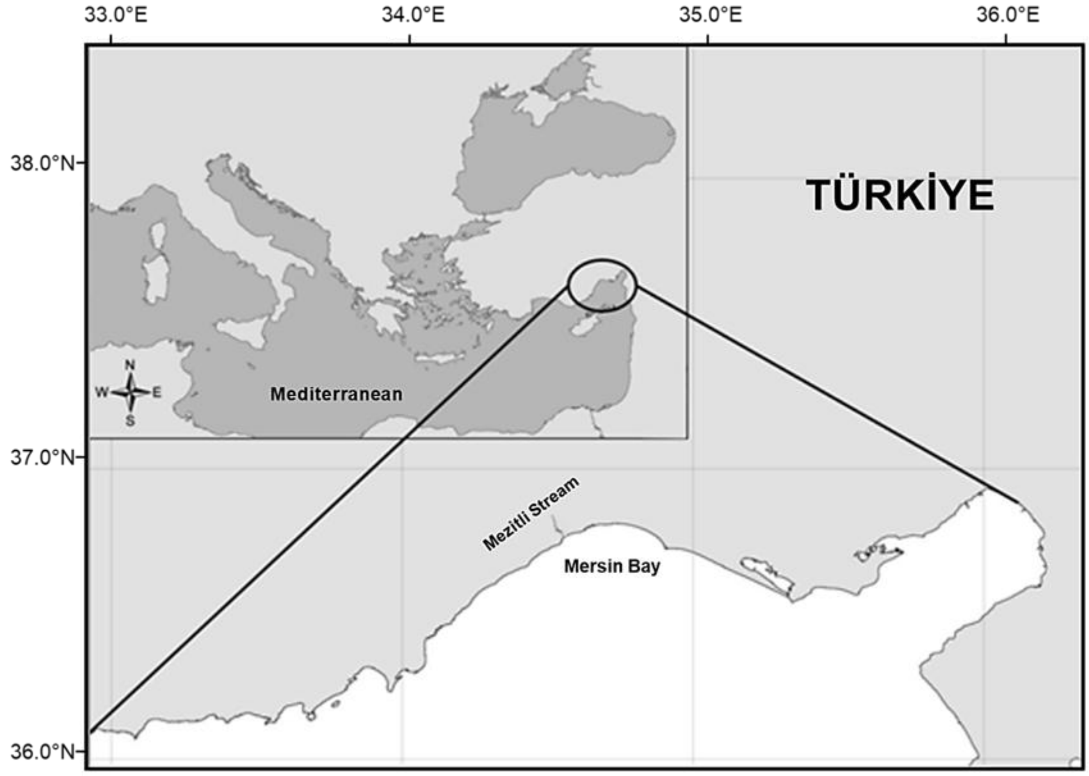

Figure 1. Map showing the sampling point at Mezitli Stream in Mersin Bay (northeastern Mediterranean).

Table 1. Geographical coordinates and depths of sampling stations.

Stations	Latitude (°N)	Longitude (°E)	Depth during dry season (m)	Depth during wet season (m)
Station 1	36.4519	34.3204	1.5	1.5
Station 2	36.4490	34.3256	2.5	2.5
Station 3	36.4529	34.3229	3.0	3.0
Station 4	36.4519	34.3236	2.5	2.5
Station 5	36.4593	34.3270	0.5	1.5
Station 6	36.4507	34.3224	0.5	1.0

Sediment-Based Measurements and Macrozoobenthic Sample Preparation

Sediment samples were collected using a Van Veen Grab sampler (de Almeida et al., 2016). Oxidation-reduction potential (ORP) was measured immediately after sampling to assess factors affecting ecosystem health, such as sediment oxygen status, organic matter accumulation, and microbial activity. The ORP of the sediment surface was measured at a depth of about 3 cm using a portable multi-parameter probe and a platinum redox electrode, and the measurements were recorded in millivolts (mV). Negative ORP values signify prevailing anaerobic conditions, whereas positive values indicate the presence of oxygen (Shirahata et al., 2012).

Sediments were then filtered through a 500 µm mesh sieve to separate macrozoobenthic organisms. The specimens were preserved in 10% ethyl alcohol and transported to the laboratory for analysis. The identification of species was conducted through the utilization of a binocular dissecting microscope.

Data analysis

Statistical analyses were conducted using IBM SPSS Statistics version 19.0 (IBM Corp., Armonk, NY, USA). Shannon-Weaver Diversity Index (*H'*), Margalef's Species Richness (*d*), and AMBI (AZTI's Marine Biotic Index) were used to evaluate the ecosystem health of the Mezitli Stream mouth.

Shannon Index (Shannon and Weaver, 1949) was applied to assess species distribution and diversity in the Mezitli Stream mouth ecosystem, evaluating the contribution of macrozoobenthic species abundance in the area to overall species diversity using the following formula:

$$H' = -\sum_{i=1}^{k} p_i \cdot \log_2(p_i)$$

where k is the total number of species, p_i is the proportion of individuals belonging to species i, and $\log_2(p_i)$ is the logarithm of p_i to the base 2.

Margalef Index was used to evaluate species richness at the mouth of Mezitli Stream by normalizing the number of species to the total number of individuals there and was calculated with the following formula (Margalef, 1958):

$$d = \frac{S-1}{\log_2(n)}$$

where S is the total number of species observed in the community, n is the total number of individuals, and $\log_2(n)$ is the logarithm of n to the base 2.

AMBI was utilized to assess the levels of organic pollution and ecological degradation in the area based on the macrozoobenthic species composition in the Mezitli Stream mouth ecosystem (Borja et al., 2019). The index was determined using the percentage of species distributed across five tolerance groups, following the formula:

$$\text{AMBI} = \frac{(0 \cdot \%G_{I}) + (1.5 \cdot \%G_{II}) + (3 \cdot \%G_{III}) + (4.5 \cdot \%G_{IV}) + (6 \cdot \%G_{V})}{100}$$

Here, $\%G_I - \%G_V$ express the percentage distribution of species belonging to each group in the total community, namely Group I (sensitive to pollution), Group II (tolerant to slight pollution), Group III (tolerant to moderate pollution), Group IV (second-order opportunistic species) and Group V (first-order opportunistic species), respectively. The obtained AMBI score represents “High” in the range of 0.0 – 1.2, “Good” in 1.2 – 3.3, “Medium” in 3.3 – 4.3, “Poor” in 4.3 – 5.5 and “Poor” in 5.5 – 7.0. Thus, AMBI provided a biologically based and holistic assessment of the water quality of the Mezitli Stream mouth ecosystem.

Result and Discussion

Detailed analysis of macrozoobenthic samples taken from six stations at the mouth of Mezitli Stream revealed significant differences in community structure depending on seasonal changes and sampling depth. These findings indicate that species composition, abundance and distribution patterns in benthic ecosystems are greatly affected by temporal and spatial environmental factors. Tables 2 and 4 present the distribution of benthic macroinvertebrates and Margalef index values for dry and wet seasons, respectively, revealing seasonal variation in species richness and abundance among stations. In general, higher richness was observed during the wet season, especially at offshore stations. Complementing these patterns, Tables 3 and 5 present ecological quality indicators and disturbance classifications based on AMBI scores, Shannon diversity and sensitivity group composition. Species were divided into five pollution-tolerance groups (I–V) to assess environmental disturbance.

The distribution of benthic macroinvertebrates and Margalef indices at six sampling stations during the dry season were presented in Table 2. A total of 109 individuals representing 18 taxa were documented, with Station 2 showing the highest abundance (39 individuals), followed by Station 3 (28 individuals). These two stations also recorded the highest Margalef Index values (2.588 and 2.484, respectively), reflecting a relatively diverse and species-rich community structure. The prevalence of species such as *Mangelia* sp., *Ringicula auriculata*, *Corbula gibba*, and *Cerithium scabridum* at these stations indicates the presence of moderately favorable environmental conditions capable of sustaining ecologically sensitive taxa. Stations 1 and 4, each comprising 16 individuals, exhibited intermediate diversity levels with Margalef values of 1.890 and 1.927, respectively. Despite having the same number of individuals, the species composition varied between the two stations: *Donax* sp. and *Donacilla cornea* were dominant in Station 1, while Station 4 displayed a higher prevalence of *Cerithium scabridum* and *Alvania fractospira*. This variation suggests local-scale heterogeneity in environmental conditions or microhabitat preferences influencing species assemblages. In contrast, Stations 5 and 6 had the lowest abundance (5 individuals each) and the lowest scores of richness (0.950 and 0.500, respectively). These findings indicate a severely degraded benthic environment, likely resulting from increased organic loads or diminished oxygen levels. The near-exclusive presence of *Nereis* sp. in these stations further supports this interpretation, as this taxon is well-known for its high tolerance to pollution and hypoxic conditions. Thus, offshore (especially Stations 2 and 3) or less impacted stations exhibited higher diversity and abundance, whereas nearshore (Stations 5 and 6) or environmentally stressed sites harbored only a small number of pollution-tolerant species.

Table 2. Distribution of benthic macroinvertebrates and Margalef's index of the stations in the dry season.

Species	Classification	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Abra sp.	Bivalvia	2	1	0	1	0	0
Alvania discors	Gastropoda	1	3	2	0	0	0
Alvania fractospira	Gastropoda	0	0	3	3	0	0
Cerithium scabridum	Gastropoda	1	3	2	4	0	0
Cerithium sp.	Gastropoda	3	3	0	1	1	1
Conomurex persicus	Gastropoda	0	1	0	0	0	0
Corbula gibba	Bivalvia	0	4	3	0	0	0
Donax sp.	Bivalvia	5	3	2	2	0	0
Donacilla cornea	Bivalvia	2	3	0	3	0	0
Mangelia sp.	Gastropoda	0	4	4	0	0	0
Ringicula auriculata	Gastropoda	1	4	3	0	0	0
Nereis sp.	Polychaeta	0	0	0	0	3	4
Ocenebra sp.	Gastropoda	0	1	1	0	0	0
Parvicardium scriptum	Bivalvia	0	4	2	1	0	0
Timoclea ovata	Bivalvia	1	0	1	1	0	0
Pusillina lineolata	Gastropoda	0	3	2	0	1	0
Tellina sp.	Bivalvia	0	1	1	0	0	0
Tritia pygmaea	Gastropoda	0	1	2	0	0	0
Margalef's Index		1.890	2.588	2.484	1.927	0.950	0.500
Total number of individuals per station		**16**	**39**	**28**	**16**	**5**	**5**
Total number of individuals in all stations				**109**			

Figure 2A shows the relative abundance of individuals among stations. The highest macrozoobenthic relative abundance at the mouth of the Mezitli Stream was recorded at Stations 2 (36%) and 3 (26%), whereas Stations 5 and 6 exhibited the lowest relative abundance at merely 4%. Figure 2B indicates the distribution of individuals collected from all stations based on taxonomic groups. Gastropoda constituted the majority of the community, at 56% (10 individuals), followed by Bivalvia at 39% (7 individuals); Polychaeta accounted for only 5% (1 individual).

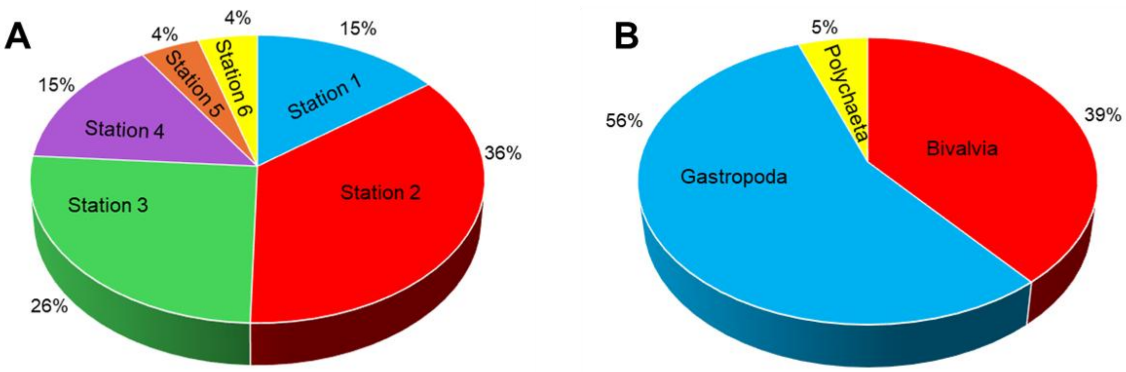

Figure 2. Relative abundances of macrozoobenthic organisms obtained from each station during the dry season (A) and classification of all observed species (B).

Distribution of species sensitivity groups (I–V), Shannon index values, AMBI scores and disturbance classification of six sampling stations in the dry season were summarized in Table 3. Stations 1, 3 and 4 were classified as "Undisturbed" with low AMBI values (0.90, 1.17 and 0.66, respectively) and relatively high proportion of sensitive species (Group I: 53.33%, 47.83% and 62.50%). These stations also exhibited high Shannon index values (1.89–1.93) and moderate species numbers (8–13 species), indicating stable and ecologically balanced benthic communities. Station 2 was classified as "Slightly disturbed" with an AMBI score of 1.24 and a relatively diverse macrozoobenthic community. Although still dominated by sensitive and irrelevant species (Groups I and II covering 85.30%), a small presence of tolerant species from Group IV (11.77%) indicates a small environmental stress. However, Station 2 showed the highest diversity (H' = 2.59) and number of species (15), reflecting relatively favorable ecological conditions compared to other stations. Conversely, Stations 5 and 6 showed obvious signs of ecological degradation. Station 5, classified as "Moderately disturbed", had an AMBI score of 3.70 and a high proportion of Group III species (60%), indicating a decrease in diversity and an increased dominance of pollution-tolerant taxa. Station 6 showed the most severe degradation, with an AMBI score of 4.77 and an almost complete dominance of Group III and II species (96.80% and 82.00%, respectively). Shannon index (0.50) and species richness (2) were the lowest recorded, further confirming a heavily impacted benthic environment. Hence, AMBI values and corresponding biotic indices in dry season effectively differentiated between degraded and undegraded areas, emphasizing the impact of organic pollution and habitat conditions on benthic community structure.

Table 3. Key ecological quality indicators and disturbance classification of each station in the dry season.

Stations	I (%)	II (%)	III (%)	IV (%)	V (%)	Shannon Index	Species Number	BI	AMBI	Disturbance classification
Station 1	53.33	33.33	13.33	0.00	0.00	1.89	8	1	0.90	Undisturbed
Station 2	44.12	41.18	2.94	11.77	0.00	2.59	15	2	1.24	Slightly disturbed
Station 3	47.83	39.13	0.00	13.04	0.00	2.48	13	1	1.17	Undisturbed
Station 4	62.50	31.25	6.25	0.00	0.00	1.93	8	1	0.66	Undisturbed
Station 5	20.00	60.00	60.00	0.00	0.00	0.95	3	3	3.70	Moderately disturbed
Station 6	0.00	82.00	96.80	0.00	0.00	0.50	2	4	4.77	Heavily disturbed
		Mean				1.72±0.83	2.38±1.26	2±1.26	2.07±1.72	Slightly disturbed

The distribution of benthic macroinvertebrates and Margalef indices at six sampling stations during the wet season were presented in Table 4. A total of 211 individuals were recorded, with the highest numbers at Station 3 (58) and Station 2 (56). These stations also had the greatest species richness, as indicated by Margalef index values of 3.14 and 3.051, suggesting favorable ecological conditions and balanced benthic structures. Dominant taxa included *Mangelia* sp., *Tellina* sp., *Mitromorpha olivoidea*, and *Tritia pygmaea*, alongside sensitive species such as *Alvania discors* and *Patella* sp. Station 1 showed moderate abundance (37 individuals) and diversity (Margalef index: 2.602), while Station 4 (30 individuals; Margalef index: 2.748) featured a well-distributed assemblage. In contrast, Stations 5 and 6 exhibited lower abundance and richness. Station 5 had 18 individuals (Margalef index: 2.366), and Station 6 recorded only 12 individuals with the lowest

Margalef index (1.234), dominated by tolerant species like *Nereis* sp. and *Lumbrineris latreilli*. The results indicate richer offshore communities and stressed nearshore environments.

Table 4. Distribution of benthic macroinvertebrates and Margalef Richness Index of the stations in the wet season.

Species	Classification	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Abra sp.	Bivalvia	2	4	1	1	0	0
Alvania discors	Gastropoda	2	2	4	3	1	0
Cerithium sp.	Gastropoda	2	1	2	3	1	0
Columbella sp.	Gastropoda	1	0	1	0	0	0
Conomurex persicus	Gastropoda	0	2	0	1	0	0
Conus sp.	Gastropoda	0	0	1	0	0	0
Corbula gibba	Bivalvia	2	4	3	3	1	0
Donacilla cornea	Bivalvia	0	1	1	0	0	0
Donax sp.	Bivalvia	0	0	2	0	0	0
Granulina sp.	Gastropoda	0	1	1	0	0	0
Hediste diversicolor	Polychaeta	0	0	0	0	2	1
Lumbrineris latreilli	Polychaeta	0	0	0	0	1	2
Donacilla cornea	Bivalvia	3	2	3	1	1	0
Mangelia sp.	Gastropoda	3	2	4	2	1	1
Ringicula auriculata	Gastropoda	0	1	0	0	0	0
Mitromorpha olivoidea	Gastropoda	5	2	4	0	1	0
Musculus costulatus	Bivalvia	0	1	2	0	0	0
Nereis sp.	Polychaeta	0	0	0	1	5	7
Obtusella intersecta	Gastropoda	0	2	0	2	1	1
Ocenebra sp.	Gastropoda	2	3	4	2	1	0
Odostomia sp.	Gastropoda	4	2	2	1	0	0
Ostrea sp.	Bivalvia	0	0	1	0	0	0
Parvicardium scriptum	Bivalvia	0	4	3	0	0	0
Patella sp.	Gastropoda	0	2	2	0	0	0
Similipecten similis	Bivalvia	0	0	1	0	0	0
Pitar rudis	Bivalvia	4	5	2	2	0	0
Timoclea ovata	Bivalvia	2	1	2	1	0	0
Pusillina lineolata	Gastropoda	1	2	0	2	0	0
Raphitoma sp.	Gastropoda	0	3	2	1	0	0
Rissoa sp.	Gastropoda	0	0	2	0	0	0
Septifer cumingii	Bivalvia	0	0	1	0	0	0
Tellina sp.	Bivalvia	3	2	4	2	1	0
Tritia pygmaea	Gastropoda	1	5	3	2	1	0
Ruditapes decussatus	Bivalvia	0	2	0	0	0	0
Margalef's Index		2.602	3.051	3.14	2.748	2.366	1.234
Total number of individuals per station		**37**	**56**	**58**	**30**	**18**	**12**
Total number of individuals in all stations				**211**			

Figure 3A shows the relative abundance of individuals among stations. The highest macrozoobenthic relative abundance at the mouth of the Mezitli Stream was recorded at Stations 2 and 3 (27%), whereas the lowest was at Stations 5 (8%) and 6 (6%). Figure 3B indicates the distribution of individuals collected from all stations based on taxonomic groups. Gastropoda constituted the majority of the community, at 50% (17 individuals), followed by Bivalvia at 41% (14 individuals); Polychaeta accounted for only 9% (3 individuals).

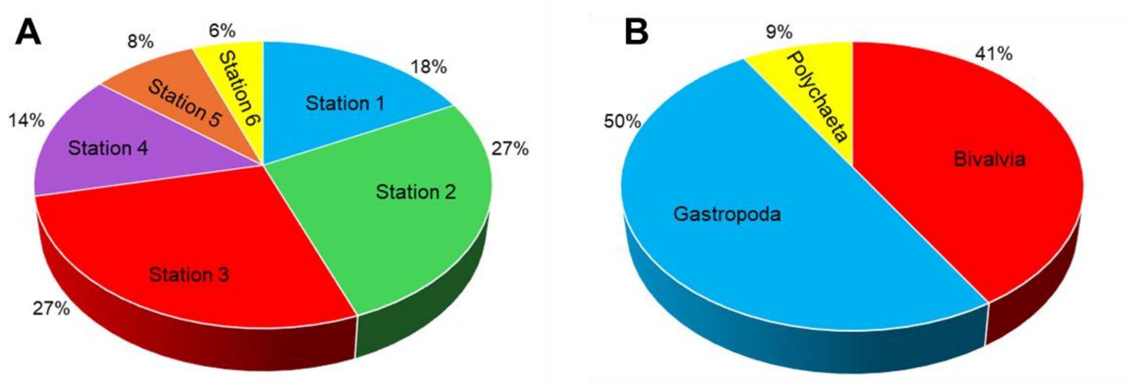

Figure 3. Relative abundances of macrozoobenthic organisms obtained from each station during the wet season (A) and classification of all observed species (B).

Distribution of species sensitivity groups (I–V), Shannon index values, AMBI scores and disturbance classification of six sampling stations in the wet season were summarized in Table 5. Stations 1, 2 and 3 were classified as “Undisturbed” based on low AMBI scores (1.09, 0.95 and 0.80, respectively), high proportions of Group I taxa (43.24%, 58.18% and 60.34%) and high Shannon diversity values (2.60, 2.91 and 3.14). These stations exhibited the highest species richness, ranging from 15 to 26 species, indicating favorable environmental conditions that foster complex and stable benthic communities. Sensitive and irrelevant species were dominant, while opportunistic taxa in Groups IV and V were either absent or negligible. Especially, Station 2 showed optimum ecological conditions with high species richness (24) and the second highest Shannon index (2.91) despite being located close to the mouth of the stream. Station 3, which recorded the lowest AMBI score (0.80) and the highest diversity index (3.14), further reflects a minimally degraded habitat with low anthropogenic pressure. In contrast, Stations 4, 5 and 6 were categorized as “Slightly disturbed” with AMBI scores ranging from 1.30 to 2.37. Station 6 showed clear signs of degradation, with the number of species decreasing to five, the Shannon index to 1.23, and Group III species becoming dominant (66.67%). This probably reflects a simplified and stress-tolerant community structure due to oxygen depletion or organic enrichment. Therefore, the results show that offshore or better oxygenated stations (1–3) maintained a more diverse and sensitive fauna, while nearshore or affected areas (especially Station 6) exhibited less diversity and an increasing prevalence of tolerant taxa.

Table 5. Key ecological quality indicators and disturbance classification of each station in the wet season.

Stations	I (%)	II (%)	III (%)	IV (%)	V (%)	Shannon Index	Species Richness	BI	AMBI	Disturbance classification
Station 1	43.24	45.95	5.41	5.41	0.00	2.60	15	1	1.09	Undisturbed
Station 2	58.18	27.27	7.27	7.27	0.00	3.05	24	1	0.95	Undisturbed
Station 3	60.34	31.03	3.45	5.17	0.00	3.14	26	1	0.80	Undisturbed
Station 4	40.00	43.33	6.67	10.00	0.00	2.75	17	2	1.30	Slightly disturbed
Station 5	27.78	27.78	38.89	5.56	0.00	2.37	13	2	1.83	Slightly disturbed
Station 6	8.33	25.00	66.67	0.00	0.00	1.23	5	2	2.37	Slightly disturbed
		Mean				2.52±0.69	16.67±7.66	1.50±0.55	1.39±0.60	Slightly disturbed

Oxidation-reduction potential (ORP) based sediment analysis revealed the spatial and seasonal variability of redox conditions. Low ORP values were recorded at all stations during the dry season, and especially at Station 6 (-242.4 mV) and Station 5 (-197.9 mV), which are the regions under the influence of Mezitli Stream, it was determined that oxygen was minimal and anaerobic conditions were dominant. Similarly, Station 4 represented a severely reduced environment with -164.8 mV. On the other hand, relatively higher ORP values measured at Stations 1, 2 and 3 close to offshore (-82.1 mV, -84.1 mV and -69.7 mV) reflect more oxygenated and less reduced conditions. A general increase was observed in ORP values during the wet season, and this was attributed to the improvement of oxygenation in the sediment environment as a result of the increased freshwater inflow with seasonal rainfall. The highest value was measured at Station 3 with -61.7 mV. However, the ORP values at Stations 5 and 6 remained quite low (-182.0 mV and -202.1 mV) even in the wet season, indicating that degradation conditions continued. An inverse relationship was found between ORP values and organic matter accumulation and oxygen availability; in this context, ORP was evaluated as a complementary environmental indicator reflecting the oxidative capacity and pollutant degradation potential of the sediment. Comparative and seasonal data for this dynamic redox environment were visualized in Figure 4.

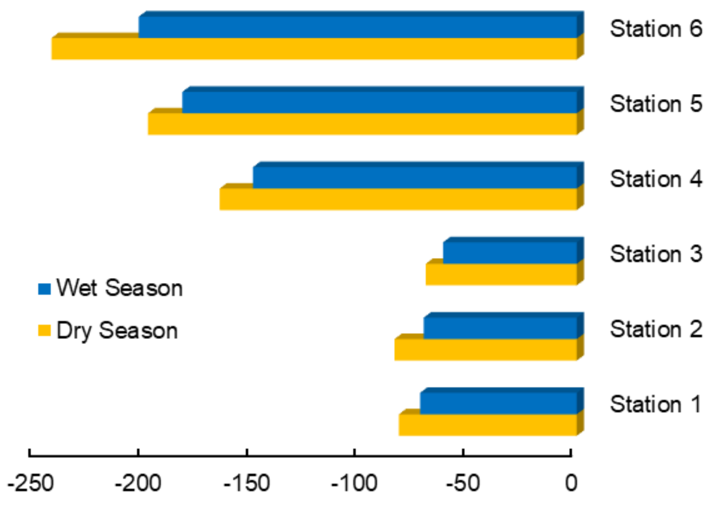

Figure 4. Distribution of ORP values measured in dry and rainy seasons at six stations.

Overall, the findings of this study reveal that the benthic ecosystem at the mouth of the Mezitli Stream exhibits heightened sensitivity to coastal pollution, aligning with previous research conducted along the Turkish coastline (Kazancı et al., 1997; Doğan et al., 2004; Albayrak et al., 2006). In accordance with the suggestions of Rosenberg and Resh (1992), Allan et al. (1997), and Borja et al. (2000), the accumulation of organic matter and anthropogenic inputs, especially from agricultural and urban sources, negatively affects macrozoobenthic community structure and biodiversity.

Stream mouths are ecologically dynamic habitats enriched by nutrients and organic matter flows. Brackish water environments formed by the mixing of freshwater and seawater generally support high biodiversity (Day et al., 1989; Attrill, 2002). However, these transition zones are also highly susceptible to anthropogenic stressors such as eutrophication, sedimentation and contamination (Kennish, 2002; Duarte, 2009). Macrozoobenthic fauna, which are key mediators in aquatic food webs, serve as reliable indicators of ecosystem functioning. Therefore, assessing their abundance, biomass and diversity is important to assess ecological integrity and guide conservation strategies (Pearson, 1978; Warwick, 1993).

This study provided a comparative assessment of macrozoobenthic communities during the dry and wet seasons and at different depths. Seasonal variation had a significant effect on community structure. During drought periods, reduced organic input due to low water levels and limited rainfall led to nutrient depletion and reduced oxygen availability, which restricted the reproductive and developmental success of several taxa (Gray et al., 2002). In contrast, the wet season was characterized by increased freshwater input, higher organic loads, and improved oxygen distribution, which collectively led to increased species abundance and diversity. At some locations, population levels almost doubled compared to the dry season.

Station-specific analyses revealed spatial variation, with Station 2 exhibiting higher diversity during the dry season, likely due to its deeper depth, increased current exposure, and higher oxygen and nutrient availability, and Station 3, located closer to the open sea, recording the highest diversity during the wet season, likely facilitated by increased light penetration, oxygenation, and nutrient accumulation. Such patterns are consistent with previous findings that greater water exchange and open-sea influence are generally associated with improved benthic diversity and ecological stability (Hyland et al., 2005; Balsamo et al., 2012). Although transient increases in diversity were observed during summer algal blooms in shallow areas, oxygen depletion in deeper layers (probably due to sulphide accumulation) disrupted benthic stability at certain stations. In support, as suggested by Borja et al. (2000) and Grall and Chauvaud (2002), this resulted in the proliferation of pollution-tolerant taxa such as *Nereis* sp., a genus commonly associated with low-oxygen, organic-enriched conditions.

ORP analyses conducted in this study confirmed that benthic sediments in the region carry a significant pollution load. Biological activity was significantly suppressed in detritus-rich, low-oxygen zones. These observations are in line with established literature indicating that such environments are generally associated with high organic matter and depleted redox potential (Fenchel and Riedl, 1970; Kristensen, 2000).

In conclusion, the findings highlight the urgent need for regular ecological monitoring and pollution control to protect the Mezitli Stream mouth and provide a valuable basis for sustainable coastal ecosystem management and provide a scientific basis. As anthropogenic pressure continues to increase, biodiversity and ecosystem functioning in the region will also be threatened. Therefore, integrated conservation strategies should be prioritized to reduce long-term ecological degradation.

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Conflict of Interest

The authors declare that for this article, they have no conflict of interest.

Author Contributions

C.K. and Ö.Ş. arranged the original draft and performed the sampling and methodology. D.A. and A.A.A. enhanced the conceptual framework, conducted the investigation, and managed visualization and editing. D.A. and M.C.A. contributed to the original draft, participated in the review and editing process, and completed the final check.

Ethical Approval Statements

No ethics committee permissions are required for this study.

Data Availability

The data used in the present study are available upon request from the corresponding author.

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