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Mini Bio-Ecological Scale Indicators Used in Comparison of Water Quality Criteria of Wetlands

Burcu Yeşilbudak
Department of Biology
Çukurova University
Adana, Türkiye

***Abstract*—Stream biodiversity has been greatly affected by the human factor in recent years. And recent studies have shown that freshwater ecosystems, which are forced to succession due to anthropogenic reasons, can affect in-stream habitats and macroinvertebrate communities in various ways and even negatively. Some species of stream macroinvertebrates survive only in uncontaminated wetlands but are sensitive and specific keystones for the stream parts they inhabit. They also act as bio-ecological scale mini-indicators of changing stream ambiance. In this regard, while the water quality of water samples taken from two different habitats of the Karamenderes River (Turkey) were analyzed in the current study, a preliminary study was conducted to determine the macroinvertebrate species diversity indices sampled from the same regions. Analytical methods were used to determine the water quality criteria. Macroinvertebrate samples were obtained with Quadrat and Ekman Birge Grab (15x15 cm), and a practical hand lens, light microscope and various literatures were used for species identification. When the physical and chemical analyzes of the water in the lower and upper stream habitats were compared, statistical differences were found ($p<0.05$), but no risk to human health was observed in either stream structure. Even with small changes in water quality criteria, significant differences in species distribution were found. It can be concluded that external factors such as physical environmental conditions and water quality criteria are very important in habitat selection, distribution, ecological niches of macroinvertebrates.**

Keywords—bio-ecological scale; mini-indicators; stream ambiance; water quality criteria

I. INTRODUCTION

Macroinvertebrates serve as sources of organic matter (e.g. leaf litter, algae, stone chips) and as the main key point of the food web between fish [1]. Considering their importance as bioindicators, macroinvertebrate studies are central to wetland ecology [2]. Macroinvertebrates in aquatic ecosystems are easy to sample from their environment, and their taxonomic definitions are simple, and they are low-cost but important indicators in determining biological quality. They are used as indicators to assess any environmental degradation or change in rivers and wetlands [3]. If the water quality is good, many species can be observed, while if the water quality is bad, only a few species can be seen [4]. It manifests itself as a habitat fragmentation due to the gradually changing environmental conditions of natural wetlands, as well as the distorted farmland and lagging urbanization [5,6,7,8]. As a result, due to habitat fragmentation, speciation in animal and plant populations results in uniformity [9]. Karamenderes (Skamander) River, originating from Kaz (Ida) and Ağı Mountain in Çanakkale province, is an important wetland that has been the subject of ancient literature and ecological literature [10,11]. Wetlands have an important role in preserving the hydrological strength of watersheds and contribute to the preparation of the cycle of hydrological functions [12]. But they are affected by natural means (flood and drought, mitigation, etc.) or unnaturally (anthropogenic source) over time [5,6,13]. In environmental monitoring studies, the richness, density and abundance of macroinvertebrates in wetlands vary depending on these conditions. It was aimed to determine the water quality parameters of two different habitats in the up and down parts of the Karamenderes River and to make a preliminary study by emphasizing the similarities and differences between the two regions by using the macroinvertebrate species distribution as a mini bio-ecological indicator.

II. MATERIAL AND METHODS

This study was carried out in the upstream and downstream habitats of the Karamenders River in Turkey. When we look at the physical condition of the sampling areas, one of them is in the Ayazma Nature Park on Kaz Mountain and at an altitude of about 480 m, and the other is in the Biga peninsula, which is the lowermost extension of the river, the Kumkale delta at an altitude of about 15 m [11]. The river is about 109 km in length and has minimum and maximum flows of 60-70 m^3/sn and 1530 m^3/sn, respectively [14]. The Karamenderes River is located on the Biga Peninsula in northwest Turkey (Fig. 1). In the autumn of 2018, samples were taken from the wetlands of Kumkale and Ayazma with 3 repetitions. Macrobenthic samples were obtained by passing the sludge samples taken with Quadrat and Ekman Grab (15x15 cm) through a 500 µm sieve and fixed in 4% formol solution, Merck

[15]. Habitat features were also noted. Photos were displayed with the OMAX brand light microscope. Additionally, a practical hand lens and various literatures also were used in the quantitative evaluation of the benthic samples and the identification of them [16,17,18,19,20,21,22]. The same species were counted and stored in the same sample bottles. The analytical methods of the water quality parameters of the sampling areas are given in Table 1 [23]. Turkish quality standards according to Turkish Water Pollution Control Regulation [24] and Turkish Surface Water Quality Regulation [25] are given in Table 1, as well. Diversity index calculations are available online at Omni Calculator sp.zoo. carried out with https://www.omnicalculator.com/. In the evaluation of the water quality parameter data obtained from the upper and lower streams, one-way ANOVA analysis and descriptive statistics were made, statistical evaluations were carried out with SPSS 18.0 statistical software [26].

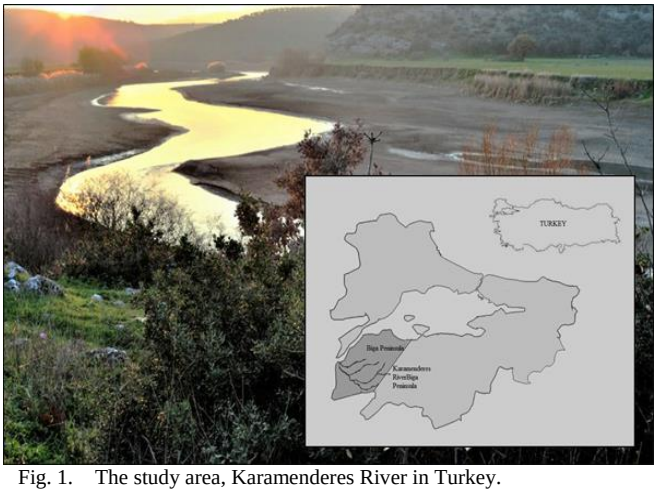

Fig. 1. The study area, Karamenderes River in Turkey.

TABLE I. ANALYTICAL METHOD PROTOCOL, UNIT AND ABBREVIATION OF WATER QUALITY PARAMETERS FOR SAMPLE AREAS

Parameters (Unit) Analytical method	Class I (Very Good)	Class II (Good)	Class III (Medium)	Class IV (Poor)
Water temperature, °C Temperature probe	25 [25]	25 [25]	30 [25]	<30 [25]
Dissolved oxygen, mg/L Oximeter	>8 [24]	6 [24]	3 [24]	<3 [24]
pH pH probe	6-9 [24]	6-9 [24]	6-9 [24]	6-9 [24]
Electrical conductivity, µS/cm Conductometry	<400 [24]	1000 [24]	3000 [24]	>3000 [24]
Total hardness, mg/L Spectrophotometry	-	-	-	-
Total organic carbon, mg/L Spectrophotometry	5 [25]	8 [25]	12 [25]	>12 [25]

III. RESULTS AND DISCUSSION

The water quality values of the upper and lower habitats of the stream are given in Table 2. Depending on the Turkish Water Pollution Control Regulation [24] and the Turkish Surface Water Quality Regulation [25], although the reference values of the Ayazma and Kumkale delta are not exceeded in extreme cases, they can be considered to be class I (very good) and class II (good) for public health. The water quality parameters of the Ayazma wetland were measured at a higher level than the values measured in the Kumkale delta, except for electrical conductivity and temperature. While there was a significant and strong difference between pH and total water hardness in the water samples taken from both regions (p<0.05). In addition, a significant difference was found between the other water parameters in the groups (p<0.05).

TABLE II. THE DESCRIPTIVE STATISTICS OF PHYSICAL AND CHEMICAL PROPERTIES OF THE WATER TAKEN FROM UPSTREAM AND DOWNSTREAM.

Upstream (Ayazma) 39°44'46.31N-26°50'35.65E Altitude: 480m	Mean ± SE	95% CI for Mean Lower-Upper Bound	Min-Max
Water temperature	12.17±0.55	9.82-14.51	11.10-12.90
Dissolved oxygen	7.44±0.16	6.76-8.12	7.12-7.60
pH	8.16±0.01	8.13-8.20	8.65-8.18
Electrical conductivity	193.67±2.96	180.92-206.41	188.00-198.00
Total hardness	312.33±1.45	306.08-318.58	310.00-315.00
Total organic carbon	2.40±0.10	1.97-2.83	2.20-2.50
Downstream (Kumkale) 36°45'49.11N-26°13'50.20E Altitude: 15m	**Mean ± SE**	**95% CI for Mean Lower-Upper Bound**	**Min-Max**
Water temperature	15.56±0.23	14.57-16.55	15.12-15.90
Dissolved oxygen	6.62±0.04	6.46-6.78	6.55-6.68
pH	7.59±0.03	7.45-7.70	7.52-7.62
Electrical conductivity	771.00±9.35	343.52-1200.48	650.00-968.00
Total hardness	250.00±2.89	237.58-262.42	245.00-255.00
Total organic carbon	1.93±0.09	1.55-2.31	1.80-2.10

Some macroinvertebrates collected from Ayazma (Fig. 2) and Kumkale wetlands (Fig. 3) were viewed. We detected caddisfly (Trichoptera) larvae, which are highly sensitive to pollution and pH levels, collected from the river sediment area in Kaz Mountain Ayazma Nature Park of Karamenderes River. In addition to Trichoptera members, acid-sensitive Ephemeroptera and Plecoptera species were also identified in the up wetland. Their presence indicates that the body of water where they live is healthy. In the sediment samples examined from this area, species that are extremely sensitive to pollution and somewhat sensitive to pollution were found [27]. It is seen that the wetland of Ayazma has high quality and in some places medium quality characteristics.

The systematic ranking of some macro benthic organisms detected in the region during the study period is given below. A total of 3391 individuals were obtained, belonging to 20 species of Oligochaeta, Mollusca, Insecta, Hirudinae, and Malacostraca (Table 3). The number of individuals and the average population in the Kumkale delta were observed 4 times and 1.13 times more than the Ayazma Stream. These mostly constitute the species belonging to the Chironomidae taxon (Fig. 4). It is thought that this may be due to the slight variation in pH or the condition of different types of unmeasured domestic waste. Although Chironomidae taxon is dominant in the soil fauna of agricultural lands, it can be an indicator showing the early time of succession. They become indicators in medium quality and poor quality areas

and are actually a taxon with a wide tolerance to pollution and not very sensitive to pollution. Their larvae and pupae constitute important food sources for some fish such as trout, killfish, salamanders, waterfowl and high-level predatory invertebrate species, contributing to an ecologically dynamic structure [28-29].

Fig. 2. Some macroinvertebrate species sampled upstream of the river.

TABLE III. TAXON OF THE BENTHIC FAUNA SPECIES DETERMINED (BLUE ARROW INDICATES UPSTREAM, ORANGE ARROW INDICATES DOWNSTREAM AREAS).

1-MOLLUSCA	4-INSECTA
Gastropoda, *Physella acuta*	Chironomidae
Bivalvia, *Pisidium sp.*	*Procladius (Holotanypus) sp.*
Bivalvia, *Mytilus galloprovincialis*	*Polypedilum nubeculosum*
2-OLIGOCHAETA	*Endochironomus tendens*
Tubifex tubifex	*Paralauterborniella nigrohalteralis*
Limnodrilus hoffmeisteri	Ephmeroptera
3-HIRUDINAE	*Caenis macrura*
Hirudo medicinalis	*Baetis rhodani*
Glossiphonia complanata	Trichoptera
5-MALACOSTRACA	*Hydropsyhe morosa*
Amphipoda	Coleoptera
Gammarus pulex pulex	*Dolophilodes distinctus*
Isopoda	Plecoptera
Asellus aquaticus	*Leuctra sp.*
	Odonata
	Cordulegaster boltonii
	Coenoagrion sp.

On the other hand, Shannon species diversity and species richness index were found to be 1.20 to 1.50 times higher in Ayazma wetland compared to Kumkale delta. Evenness index takes a value between 0-1 and a value of 1 represents the value of evenness [30]. The smoothness values in both Ayazma and Kumkale deltas were calculated as 0.98 and 0.99, which may mean that the tolerant and non-tolerant taxons actually found suitable conditions for each of them. Monitoring changes in the mini-ecosystem rather than monitoring water quality criteria alone can provide us with more precise information about changing environmental conditions in the long term.

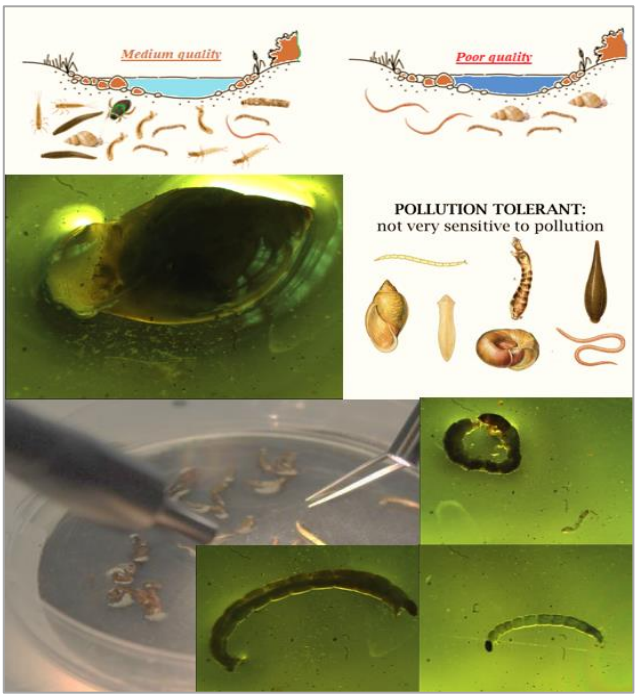

Fig. 3. Some macroinvertebrate species sampled downstream of the river.

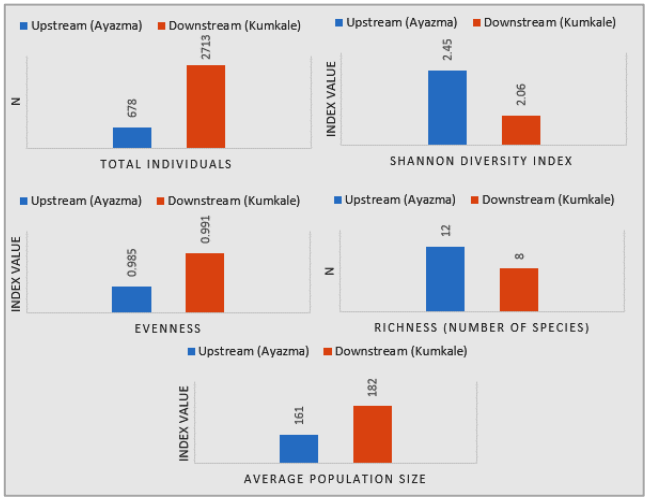

Fig. 4. Species diversity index values of macroinvertebrates sampled from different regions.

Fig. 5. Change of stream path by flood and anthropogenic effects.

IV. CONCLUSION

Wetlands are important areas where various plant and animal species gather at a common point due to their biological richness, sustainable ecological resources and nutritive element load [31]. In fact, their compositions can differ significantly depending on the fact that they are transition zones between terrestrial and aquatic ecosystems [32]. In this study, the macroinvertebrate richness of the region, which is an important wetland within the borders of Troy National Park, was investigated. It has been determined that Karamenderes Delta has a rich fauna in terms of invertebrate species. However, various anthropogenic factors (Fig. 5) have been identified in the region such as mining, river bed disturbances, and drought. It is envisaged to examine the possible effects of this situation on living things in the long term.

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