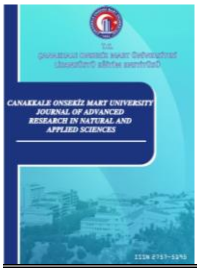
e-ISSN 2757-5195



Çanakkale Onsekiz Mart University

Journal of Advanced Research in Natural and Applied Sciences

Open Access

doi.org/10.28979/jarnas.890638 2021, Vol. 7, Issue 2, Pages: 274-281 dergipark.org.tr/tr/pub/jarnas

Assessment of Habitat Quality of Bozalan Clay Quarry Wetland (Ezine, Çanakkale) Using Macroinvertebrates and Water Quality Parameters

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Article History

Received: 03.03.2021

Accepted: 15.06.2021

Published: 30.06.2021

Research Article

Abstract − In this study, it is aimed to determine the habitat quality of the Bozalan quarry wetland by using diversity and a compositional index of benthic macroinvertebrates and some of the water quality parameters. The field studies were conducted in the three sampling sites chosen in the wetland three times (March, April, and May) in 2018. The standard multi-habitat method was used for the benthos sampling. Besides, water sampling was performed for the parameters measured in-*situ* and analyzed in the laboratory to reveal the water quality status of the wetland. Some of the diversity index values of the benthic macroinvertebrates including Shannon Wiener (H′), Evenness Index (EI), and BMWP-e were calculated. The results showed that the sampling sites were categorized into higher classes (I and II) in general according to water quality criteria of the surface waters of Turkey. Fourteen taxa of benthic macroinvertebrates were identified. The most dominant taxa were *Coenagrion* sp. (42.31%), *Baetis rhodani* (15.38%), and *Physella acuta* (10%) in the study area. The highest number of individuals of macroinvertebrates was obtained in March (62 ind./m^2), meanwhile the highest taxa number was determined in May (10 taxa). The H′ index was reached its highest value in May (1.723), whereas the lowest value of the index was in March (1.054). The highest score of the BMWP-e was found in May (26), while the lowest score was found in April (16).

Keywords *– Biodiversity, clay quarry, community index, macroinvertebrates, secondary wetland*

1. Introduction

The increasing need for energy and raw materials global-scale has been significantly contributed to environmental impacts. Mining activities are one of the main issues that draw attention to the effects of the environment including land degradation, noise, and water pollution (Dudka & Adriano 1997). Thus, environmental protection is required for the sustainable development of a country (Monjezi, Shahriar, Dehghani & Samimi Namin 2009). On one hand, an open mining operation eliminates habitats and natural communities on the surface, on the other hand, may result in new habitats such as artificial wetlands through filling the pits by precipitation and groundwater. Though these unnatural wetlands in other words, “secondary wetlands”, are mainly not designed to create a natural reserve for wildlife, these environments can be tempting for some organisms, as it visually looks like a natural aquatic environment (Dolny & Harabis, 2012). Consequently, these habitats might be promoting the local biodiversity and persist the communities (Bendell-Young et al., 2000; Scheffers & Paszkowski, 2013; Thiere et al., 2009). In contrast to natural habitats, artificial wetlands need time for the recovery of all the life forms (Zhang, Yuan & Wang, 2019), meaning that the recolonization stage of an organism begins from the first level: the introduction stage (Suding, Gross & Houseman, 2004).

Monitoring the macroinvertebrates in the natural aquatic habitats are primary elements of biological monitoring studies due to their ubiquitous dispersion and enormous species numbers (Mandaville, 2002). Thus, there is plenty of research focused on the biological monitoring using aquatic macroinvertebrates to assess the ecological quality of aquatic habitat and estimate the intensity of anthropogenic impacts (Rosenberg & Resh 1993; Borcherding & Volpers 1994). However, very little attention is paid to macroinvertebrates in the newly established habitats such as abandoned quarry wetlands (Zhang, Yuan & Wang, 2019).

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The present study is conducted on the Bozalan Clay Quarry Wetland (northwest Turkey), where the open-pit mining operation continues which covering an area of about 99 hectares. Operation area is a forest status and there is a first-degree natural protection zone approximately 650 m. far from the license border of the quarry. As the operation area has been used for clay extraction since 1980, an artificial pond as a secondary wetland has been formed at the base of the site which is partly surrounded by the reeds, most common wetland plants namely, *Phragmites* sp. and *Typha* sp. In the present study, it was aimed to evaluate the ecological status of the quarry wetland using the monitoring macroinvertebrates and some of the water quality parameters to provide information on the monitoring programs for the secondary wetlands.

2. Materials and Methods

The study area, Bozalan Clay Quarry wetland, is located near the Bozalan village, Ezine district of Çanakkale-Turkey (Northwestern Turkey) (Figure 1). The mining area is established on an area of 99.27 ha since 1980. The water-filled at the base of the operation area and then it was arranged and rehabilitated as an artificial wetland to serve biodiversity (including bird and aquatic species) under the supervision of an academic team in 2014 (Güçlü, Tokoğlu & Vardar, 2014). The water source of the wetland is mainly rainfall and a small amount of groundwater that contributes to keeping the water level at a constant level in the dry season. On the other hand, there is a spillway designed to prevent floods during the wet season. Therefore the artificial wetland has a constant level of water all year round. The maximum depth of the quarry wetland was 1.5 m at the sampling periods.

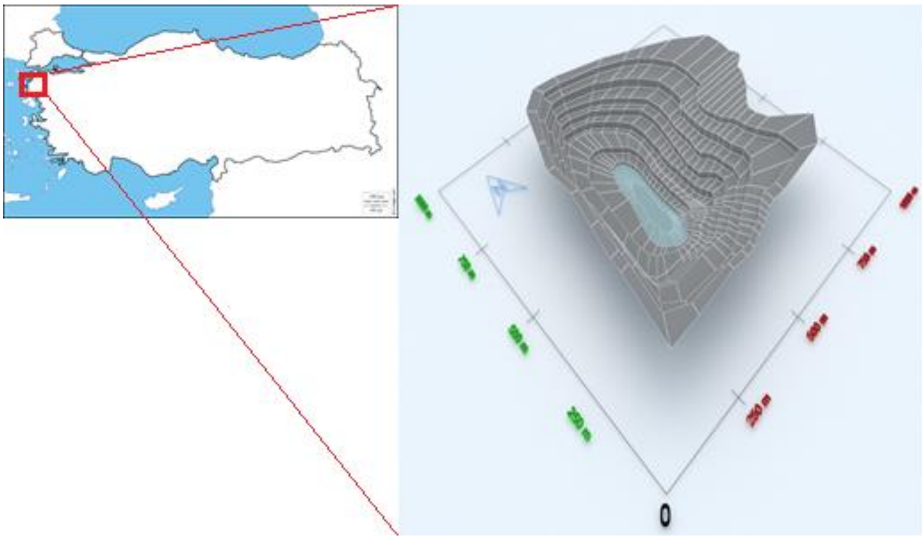

Figure 1. The study area

Three field studies were carried out on the three sampling sites preselected in the wetland in 2018. The sampling periods were March, April, and May in 2018.

Some of the physical and chemical parameters of the water including temperature, pH, electrical conductivity, total dissolved solids and dissolved oxygen were recorded in-*situ* using portable multi-parameter equipment (Hanna, HI 98194), concurrently the benthic sampling was performed in the three sampling sites. Water samples were taken into polyethylene bottles from the station 2 for determination of concentrations of some elements (i.e. B, Ba, Ca, Cd, Co, Cu, Fe, K, Mg, Mn, Na, P,) and some ions (e.g. Cl and SO_4^{-2}) and transferred to the laboratory in a cool place. Element and ion analysis were performed by ICP-OES (with the range of 160-900 nm) and classical method (TS4164 ISO9297, SM4500 SO_4^{-2}D) respectively in Çanakkale Onsekiz Mart University, Science and Technology Application and Research Center. For the determination of the microbiological load, water samples were taken into sterile-dark glasses bottles (250 ml). All the samples were kept under cool conditions using an insulated box to transferring to the laboratory of Microbiology, Faculty of Marine Science and Technology (ÇOMU). Inoculation was made to reveal the Total Aerobic Bactreia Count (TAB) (log-n cfu/ml), Total Coliform (TC) (log-n cfu/ml), Fecal Coliform (FC) (log-n cfu/ml), and Fecal *Streptococcus* (FS) (log-n cfu/ml). Plate Count Agar (PCA) (Merck 1.05463), Violet Red Bile Agar (VRB) (Merck 1.014060), and D-Coccosel Agar (DCA) (bioMérieux) were used in Total Aerobic Bacteria Count, Total and Fecal Coliform, and Fecal Streptoccus, respectively. The spread plate method was performed in microbiological inoculations. Total Aerobic Counts is intended to determine the microbial density in the surface water. This method was applied into PCA for 24-48 hours at 37 °C using cooled incubator. The same procedure was applied to Total Coliform and Fecal Streptococcus inoculations using VRB Agar. Fecal Coliform was applied into DCA for 24-48 hours at 44.5 °C (FDA-BAM 2001; Halkman 2005).

The benthic macroinvertebrates community was sampled with a standard multi-habitat-sampling method by using hand-net (covering area: 0.0625 m^2, 0.5 mm mesh size; ISO 10870:2012) from the different representative locations in the wetland. After sampling, the samples transferred to the laboratory. The samples washed by tap water and the macroinvertebrates were sorted and then fixed by ethanol (80%). Identification was made under binocular and stereo microscope. All macroinvertebrates were identified to the lowest feasible taxonomic level and counted. For Identifications Şahin (1991), McCafferty (1981), Glöer (2015) were used.

Dominance and frequency percentages of the macroinvertebrates were calculated according to formula mentioned by Kazancı & Dügel (2000). Some biodiversity indices including Shannon wiener (H') and Evenness index (EI) of the benthic macroinvertebrates were calculated using PAST (ver1.75. On the other hand, Spanish version of biological monitoring working party (BMWP-e), a compositional index, was calculated.

3. Results and Discussion

3.1. Physical and Chemical Parameters

Water quality parameters that were measured in-*situ* are showed very limited fluctuation between sampling periods. All parameters are in acceptable ranges according to the Water Quality Criteria Legislation of Turkey (WQCL) (Anonymous, 2015). pH levels were varied between 7.39 and 7.74. Dissolved oxygen (DO) concentrations were varied between 3.63 and 5.08 ppm, in the II and III of the WQCL category. The temperature (T) of water fluctuated in parallel with the atmospheric temperature. Electrical conductivity (EC) values were nearly constant in all sampling periods. All total dissolved solids (TDS) levels were categorized as class II according to the WQCL except first and third sampling sites in May. TDS values of the sampling sites were found in correlation with the EC values (Table 1).

Table 1
Water quality parameters of clay quarry wetland measured In-*situ* with the water quality classes.

Date	Station	pH	DO (ppm)	T (ºC)	EC (µS/cm)	TDS (ppm)
5.03.2018	1	7.70	3.63 (III.)	15.3	1530	767 (II.)
	2	7.74	4.09 (II.)	17.3	1583	791 (II.)
	3	7.42	4.48 (II.)	14.01	1480	740 (II.)
5.04.2018	1	7.39	5.08 (II.)	14.1	1467	729 (II.)
	2	7.69	3.92 (III.)	21.96	1429	738 (II.)
	3	7.54	4.46 (II.)	16.3	1355	678 (II.)
29.05.2018	1	7.47	4.48 (II.)	23.1	1567	424 (I.)
	2	7.55	4.21 (II.)	22.76	1412	518 (II.)
	3	7.36	4.01 (II.)	21.3	1511	387 (I.)

Considering the element and ion parameters of the water were compared to WQCL. Accordingly, chlorine (Cl) concentration was in class IV respectively. Apart from Cl, all the concentrations of ions were found in acceptable ranges (WQCL Class I) (Table 2). The water quality parameters that were measured in this study showed that the artificial wetland could be used as a recreational purpose.

Table 2.
Element and ion concentrations of the clay quarry wetland water.

Parameter	Value		
	05.03.2018	05.04.2018	29.05.2018
P (mg/L)	0.122	0.121	0.117
Co (µg/L)	ND	3.527	ND
Cd (µg/L)	ND	2.116	ND
Ba (µg/L)	69.24	34.55	125.70
Fe (µg/L)	8.226	20.98	11.36
B (µg/L)	30.33	19.69	ND
Mn (µg/L)	13.29	4.298	10.58
Mg (mg/L)	27.84	25.34	32.68
Ca (mg/L)	40.54	37.80	44.81
Cu (µg/L)	6.951	4.992	ND
Na (mg/L)	34.19	24.32	35.30
K (mg/L)	1.821	1.184	2.155
Cl (mg/L)	60.27	58.49	65.58
SO4-2 (mg/L)	71.78	84.29	46.93

ND: Not Determined (Out of the measuring range).

3.2. Microbiological Parameters

In the microbiological analyses, total aerobic bacteria (TAB) counts might show probable contamination to the water source. Especially in surface waters winds, precipitation, and rising temperature can be caused an increase of the TAB. According to the Ministry of Health, our TAB values were over the limitation of human consumption purpose of water legislation (Anonymous, 2016). Total aerobic bacteria counts indicate that the water of the wetland is not suitable for use domestic and household consumption, because categorized as class II by this parameter. Throughout the study period, FC and FS bacteria were not detected. Fecal coliform comes from the digestive systems of hot-blooded animals and humans (Halkman, 2005), so it could be an indication of contamination. The absence of these parameters was indicated that is no domestic discharge into the area. When TC values were compared to WQCL for surface waters, the study area can be placed into class I, because of the values below the 1.9 (log cfu/ml).According to the microbiological investigation in the present study, the water of the Bozalan wetland has good quality as surface water, however, is not suitable for drinking purpose due to the excessive values of TAB (Figure 2).

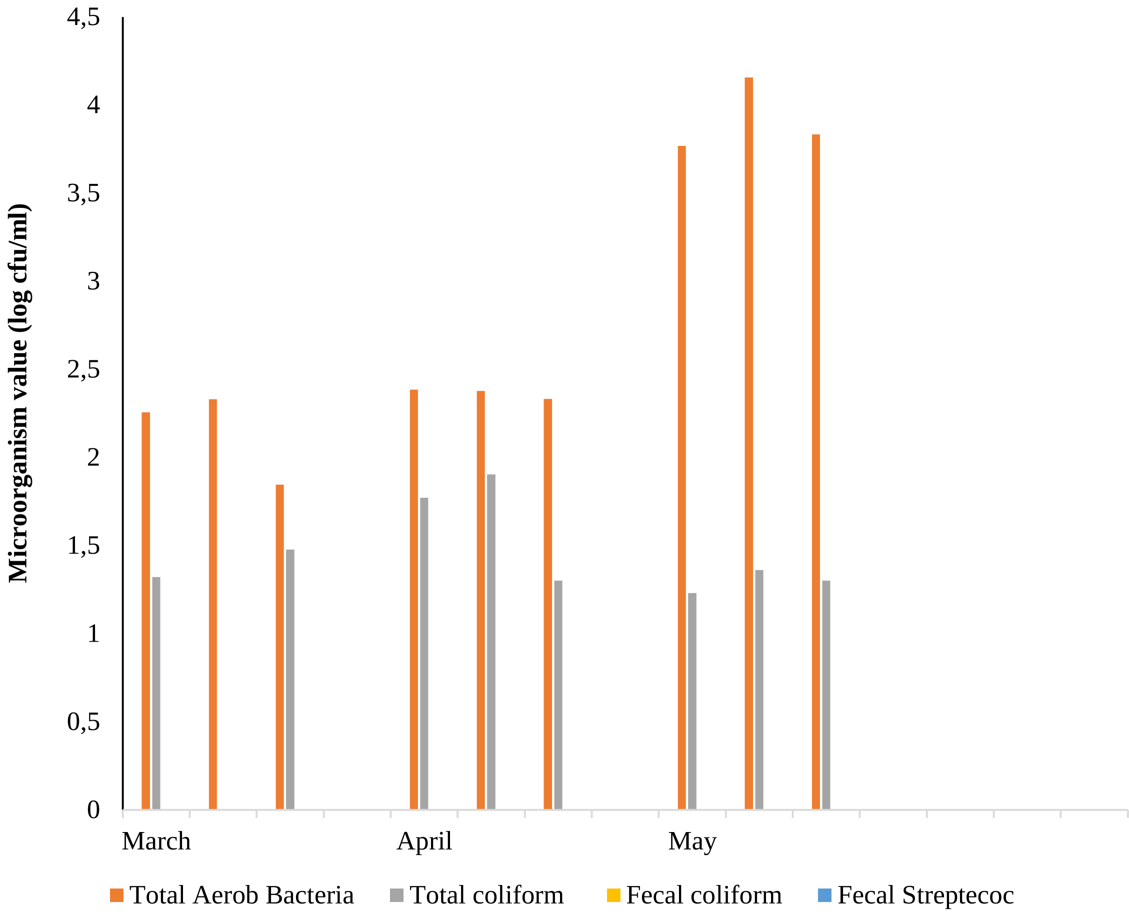

Figure 2. Microbiological data of water obtained from Bozalan Clay Quarry Stations.

3.3. Macroinvertebrates

In the study area, 14 taxa of benthic macroinvertebrates were determined. These taxa are belonging to Gastropoda (1), Insecta (12) and Malacostraca (1) class. The dominant taxa were *Coenagrion* sp. with 42.31% and *Baetis rhodani* with 15.38%, whereas the least dominant were *Corixa punctata* and *Erythemis* sp., *Potamon ibericum* and *Psectrocladius (P.) limbatellus* with 0.77%. According to the data, insect class were dominated the benthic macroinvertebrates fauna. The most frequent taxa (%) in the study area were *Coenagrion* sp. and *Tabanus* sp. with 100% (Table 3).

The most dominant taxon of the region is *Coenagrion* sp.. This genus and close relative taxon *Libellula* sp. are both known as dragonflies which are susceptible to environmental changes, thus they are highly useful ecological indicators (Simaika & Samways, 2011). Also these dragonflies are playing a vital role in the ecological restoration of post-mining freshwater wetlands (Tichánek, 2016). *Baetis rhodani* is a frequently sampled species in the region. *B. rhodani* is a widespread Ephemeropteran (mayfly) that occurs throughout the West Palaearctic. According to Meyer (1987), species belonging to *Baetis* can be found in less-polluted regions of freshwaters, categorized as I-II. Larvae of Chironomidae mostly found in stagnant waters (Şahin, 1984, 1991). In this study, it is observed that several Chironomidae taxa in the wetland. The larva of Ceratopogonidae, similarly, lives in stagnant or slow flowing waters such as marshes and temporary waters (Bouchard, 2004). Although, *Physella acuta* is one of the most widespread and invasive species in the world (Coffman, Cummins & Wuycheck, 1971; Zhadin, 1965), it was found in low individual numbers in the wetland. According to Odabaşı (2011), this species was recorded from closer water basins with a high number of individuals.

Table 3
List of the macroinvertebrates and their index values

Class	Family	Species	5.03.2018	5.04.2018	29.05.2018	D%	F%
Gastropoda	Physidae	*Physella acuta*	10	_	3	10	66.67
Insecta	Coenagrionidae	*Coenagrion* sp.	40	2	13	42.31	100
	Libellulidae	*Libellula* sp.	8	_	_	6.15	33.33
		Erythemis sp.	1	_	_	0.77	33.33
	Tabanidae	*Tabanus* sp.	3	2	2	5.38	100
	Chironomidae	*Procladius* (*H.*) sp.	_	9	1	7.69	66.67
		Cladotanytarsus mancus	_	1	_	0.77	33.33
		Einfeldia carbonaria	_	_	2	1.54	33.33
		Polypedilum aberrans	_	_	4	3.08	33.33
		Psectrocladius (P.) limbatellus	_	_	1	0.77	33.33
	Ceratopogonidae	Ceratopogonidae	_	4	2	4.62	66.67
	Corixidae	*Corixa punctata*	_	_	1	0.77	33.33
	Baetidae	*Baetis rhodani*	_	_	20	15.38	33.33
Malacostraca	Potamidae	*Potamon ibericum*	-	1	-	0.77	33.33
BMWP-e Score			21	16	26		
Taxa Number			5	6	10		
Individuals			62	19	49		
Shannon_H'			1.054	1.33	1.723		
Evenness_EI			0.574	0.756	0.5603		

Shannon Wiener is varied between 0 and 5 in general from the poor to the richest of diversity. In the present study, H' was the highest in May with 1.723 in parallel of the taxa numbers. Evenness is varied between 0 and 1, means that stability of taxa number occurring in the study area. In the present study, the highest value of EI was detected in the second period of the sampling due to balanced individual numbers per taxa. The compositional index, BMWP-e, was higher in the first and the third sampling periods with 21 and 26 respectively. The scores of BMWP-e were indicated that the ecological quality was better in the 1st and 3rd periods than the 2nd period.

4. Conclusion

In conclusion, it is thought that additional studies are required to improve our knowledge regarding taxa inventories with various metrics (i.e. diversity, tolerance, and compositional) of the macroinvertebrates which are mostly used quality components in an aquatic environment on the secondary or artificial wetlands. Thus, type-specific ecological assessments conducted on such environments could provide an informational background for water managers to implement the Water Framework Directive in Turkey.

Acknowledgement

This project was financially supported by AKÇANSA Corporation within the scope of the Quarry-Life Award international project competition in 2018. The author is grateful to the AKÇANSA corporation authorities and coordinators. I would like to thank to Çanakkale Onsekiz Mart University. I am indebted to Dr. Deniz Anıl ODABAŞI, Dr. Fikret ÇAKIR for their indisputable contributions to the study. Ömer YAVUZ, who produced the 3-D map of the study area, was also acknowledged.

Author Contributions

Author S.O.: Conducted the field and laboratory works of this study and has currently written the paper.

Conflicts of Interest

The author declares no conflict of interest.

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