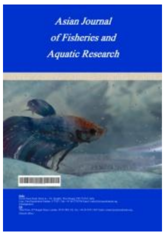

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Water Quality of Pond Irrigation Channels Based on the Community Structure of Macrozoobenthos in Legonkulon, Subang, West Java

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Authors' contributions

This work was carried out in collaboration among all authors. Author AA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors HH and RI managed the analyses of the study. Author HH managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This research aimed to analyze the quality of water in pond irrigation channels by examining the community structure of macrozoobenthos in Legonkulon, Subang Regency, West Java. The research was conducted in the Pond Irrigation Channels, Subang Regency, West Java starting from July until September 2020. This research method used a survey method using primary data in the form of physical chemistry of aquatic data, macrozoobenthos density, diversity index, uniformity index. The method used in data collecting techniques was purposive sampling in determining 4 stations and 3 repetitions. Data analysis in this research used descriptive analysis. Research results found 28 species consisting of 3 phyla, namely Mollusca, Arthropoda, and Annelida. The species that dominate the four stations are *Filopaludina javanica* and *Tarebia granifera*. Makrozoobenthos density ranges from 40 – 295 ind/m^2. Makrozoobenthos diversity index in the medium category 1.0 < H' <3.322. Uniformity values ranged from 0,43 to 0,81 with low to high category. The highest uniformity index was found at station 3, and the lowest uniformity index was

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at station 4, while at station 1 and station 2 had a moderate uniformity index. The results of the macrozoobenthos community structure showed that the water quality of the pond irrigation channels in Legonkulon was classified as being medium polluted.

Keywords: Makrozoobenthos; density; diversity indeks; uniformity indeks.

1. INTRODUCTION

Fish production in the coastal area of Subang Regency has considerable potential. Fishery activities in this area consist of catching and cultivating ponds. The utilization of pond land in the coastal area of Subang is very intensive and is spread evenly in almost every coastal district. The ponds scattered in the coastal area of Subang are used to cultivate various types of fish and shrimp.

Subang is one of the districts that produce the largest aquaculture in West Java [1]. Subang Regency in 2016 was able to produce pond-cultured fish of 34,062 tons/year. In the next three years, namely in 2019, pond cultivation production has decreased to 32,392 tons/year [2]. The significant decline in production was caused by many factors. Declining water quality is one of the factors for the decline in cultivation production that occurs in Subang Regency.

The decreasing quality of pond water can be caused by environmental degradation from domestic and non-domestic waste. Water quality can directly affect the health of the cultivated organism. Thus, maintaining water quality in the pond environment is very important for the health and growth of aquaculture organisms, so that the production of ponds can be maximized. Declining water quality will affect the physical, chemical, and biological conditions of waters. One of the biological parameters that can be used to determine water quality is macrozoobenthos. According to Nagin [3], macrozoobenthos is a biotic component that can provide an overview of water conditions. Macrozoobenthos are organisms that live on the bottom of the waters, have relatively slow movements, and can live relatively long so that they can respond to water quality conditions [4]. Macrozoobenthos can be found in all water bodies so that these organisms are easy to identify.

Based on the above problems, so that the production of pond culture in Subang Regency can be maximized, it is necessary to know the quality of water used in cultivation activities. Therefore, it is necessary to analyze the quality of water physically, chemically, and biologically in the pond irrigation channels in Legonkulon. This research aimed to determine the quality of water in the pond irrigation channels by examining the structure of the macrozoobenthos community in Legonkulon, Subang Regency, West Java.

2. MATERIALS AND METHODS

2.1 Research Time and Place

The research was carried out in July-September 2020 in a river that is a pond irrigation channel located in Pangarengan Village, Legonkulon District, Subang Regency, West Java. The method used is the survey method. The sampling technique used in this research was the purposive sampling method. The research station is divided into 4 stations, namely stations 1, 2, 3, and 4 Fig 1. The station is determined based on land use around the pond irrigation canals.

- Station 1 is agricultural land with coordinates 6º12'46.4 "LS and 107º49'25.3"BT.
- Station 2 is a residential area with coordinates 6º12'56.9 "LS and 107º49'37.4"BT.
- Station 3 is a fishing pier with coordinates 6º12'19.8 "LS and 107º50'43.7"BT.
- Station 4 is a mangrove area with coordinates 6º11'33.3 "LS and 107º50'54.3"BT.

2.2 Sampling and Measurement

Sampling was carried out at 4 stations with three repetitions. The sampling period was carried out every 14 days, and substrate sampling was carried out once in week 6. The water samples analyzed consisted of 8 parameters, that is temperature, depth, brightness, current, type of substrate, dissolved oxygen (DO), salinity, and pH carried out in situ. Macrozoobenthos identification was carried out at the Center for Natural Resources and Environmental Research, Padjadjaran University, while substrate type analysis was carried out at the Laboratory of Soil

Chemistry and Plant Nutrition (KTNT), Department of Soil and Land Resources, Faculty of Agriculture, Padjadjaran University.

2.3 Macrozoobenthos Sampling

Macrozoobenthos at each station were taken using an ekman grab. Macrozoobenthos sampling was carried out by quadratic transects which were carried out at each research station. The quadratic transect is a rectangle measuring 1 x 1 m^2. Macrozoobenthos and the substrate were separated using a filter, the substrate sample was put into a labeled plastic bag and the macrozoobenthos sample was put into a labeled bottle. 4% formalin was used to preserve macrozoobenthos samples.

2.4 Sample and Analysis

Macrozoobenthos community structure data and water quality were analyzed using comparative descriptive analysis. The data will be compared with Government Regulation of the Republic of Indonesia No. 82 of 2001. The data used for analysis is the average result of sample repetitions at each station. The analysis carried out included the abundance, diversity, and uniformity of macrozoobenthos.

2.4.1 Abundance of Macrozoobenthos

The formula used to calculate abundance is [5].

$$Di = \frac{ni}{A}$$

Description:
Information:

Di = Density of type i-individuals
Ni = Number of individuals of type i
A = Area of sample transect (m^2)

2.4.2 Macrozoobenthos Diversity

Diversity index can be calculated using the Shannon-Wiener Diversity Index (H') formula as follows [6]:

$$H' = -\sum_{i=1}^{s} (Pi)(\log_2 Pi)$$

Description:

H '= Shannon-Wiener diversity index
S = number of species
Pi = the proportion of the number of individuals of type I to the total number of individuals

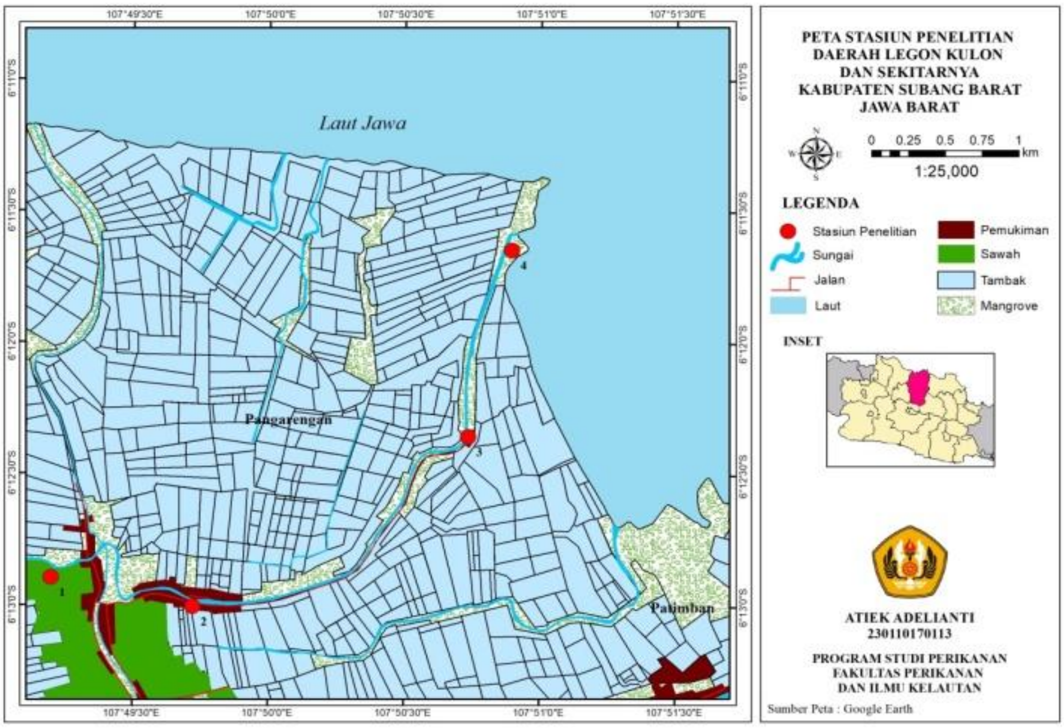

Fig. 1. Map of the Macrozoobenthos observation station

2.4.3 Uniformity of Macrozoobenthos

Uniformity can be said to be equilibrium, namely the individual components of each species contained in a community, calculated by the formula [6]:

$$E = \frac{H'}{H_{maks}}$$

Description:

E = uniformity index
H '= Shannon-Wiener diversity index
H max = Log_2S
S = number of species specified

3. RESULTS AND DISCUSSION

3.1 Macrozoobenthos Community Structure

The results showed that the highest abundance of macrozoobenthos in pond irrigation was at station 1, while the lowest abundance was at station 3 Table 3. Environmental conditions at station 1 still support the survival of macrozoobenthos such as temperatures that do not exceed the maximum limit of macrozoobenthos, is 35 - 40 ˚C, pH at station 1 is neutral, this also supports the survival of macrozoobenthos. The optimal pH value for macrozoobenthos ranges from 7 – 8.5 [7]. Also, station 1 has dissolved oxygen levels that exceed the minimum limit of oxygen tolerated by macrozoobenthos, namely 3-4 mg/L [8]. Station 1 is agricultural land as the entry point for agricultural waste which contains a lot of organic matter. Macrozoobenthos organisms that are mostly found at station 1 come from the gastropod class, this happens because the gastropod class is included in the facultative class organisms that can live in waters that contain lots of organic matter.

Station 3 has the lowest abundance of macrozoobenthos, which is 40 individuals /m^2 Table 3. The abundance of macrozoobenthos is influenced by environmental conditions that have been polluted. The life support factors for macrozoobenthos at station 3 are very low, including dissolved oxygen (DO) levels which are at the minimum limit of oxygen that is tolerated by macrozoobenthos. Also, the temperature at station 3 is quite high, this will be dangerous for the survival of the macrozoobenthos because it can suppress the population growth of macrozoobenthos. Station 3 has an average salinity which is at the highest limit of the optimum salinity range for macrozoobenthos survival, which is 36.00‰ so that the organisms found at station 3 are organisms capable of adapting to high salinity.

Based on the results of the calculation of the Shannon-Wiener Diversity Index in Table 1, the macrozoobenthos diversity index in the pond irrigation channels in Legonkulon ranges from 1.49 – 3.01. The highest diversity of macrozoobenthos was at station 3 with a value of 3.01 and the lowest at station 4 with a value of 1.49. According to Odum [6] in Herawati [9], the value of diversity is related to environmental conditions that affect the level of tolerance for macrozoobenthos because each type of macrozoobenthos has a different tolerance. The low diversity index indicates that the environmental conditions of these waters have been polluted so that only a few types of macrozoobenthos can survive. Meanwhile, a high diversity index indicates that these waters have good environmental conditions so that many types of macrozoobenthos can adapt to the aquatic environment.

The diversity index at station 3 with a value of 3.01 is included in the medium diversity category, meaning that station 3 has moderate ecological pressure so that there is an indication that pollutants enter the waters. Station 3 is a fishing dock area that is used as a berth for fishing boats. So that the source of pollution that causes ecological pressure comes from the waste that is disposed of from the activities of ships anchored at the pier. Generally, waste is in the form of plastic bottles, plastic bags, fishing gear (fishing lines, nets, and buoys), and liquid waste in the form of fish blood, diesel fuel, and leftover ice [10].

Station 4 has the lowest index value with a value of 1.49 which is also included in the medium diversity category so that it has moderate ecological pressure. Station 4 is a mangrove area that is used for ecotourism. The source of pollutants comes from the high activity of tourists in the mangrove area so that this area is accumulated by various types of waste.

Based on Table 2, it can be seen that the highest value is at station 3, which is 0.81 and the lowest is at station 4, which is 0.43, while at station 1 it is 0.67 and station 2 is 0.56. Station 3, which is a fishing pier, has a high uniformity index. This shows that at station 3 the macrozoobenthos community is evenly distributed, and no species dominates. Station 4, which is a mangrove area, has a low uniformity index Table 2, this shows that the macrozoobenthos community is depressed, and there are predominant species.

The species that dominate station 4 is *Cerithidea cingulata* from the gastropod class with a total number of 200 individuals found. The species *Cerithidea cingulata* can be used as an indicator species. Cerithidea cingulata species live in groups and have a very high breeding pattern [11]. Gastropod class macrozoobenthos can survive in substrate environmental conditions with high organic matter content and can adapt well to live in various places [9]. Because station 4 is dominated by gastropod class macrozoobenthos, it means that station 4 is polluted water.

Macrozoobenthos uniformity in the pond irrigation channels in Legonkulon at each station is uneven. Station 1 and station 2 have moderate uniformity values. This means that the macrozoobenthos community at the station is not evenly distributed and not balanced. The species that dominate station 1 are *Filopaludina javanica* and *Bythinia truncatum*, while the species that dominate station 2 are Filopaludina javanica and Tarebia granifera. The three species belong to the gastropod class. Stated that gastropods can accumulate pollutants without being killed, found in large numbers, and live for a long time [12]. Station 1 is agricultural land, land use used as agricultural land becomes the source of the entry of waste into the pond irrigation channel. Agricultural waste contains high levels of organic matter because it comes from the excessive use of fertilizers and pesticides. Meanwhile, station 2 is a residential area that produces domestic waste such as bathroom waste, water leftover from washing clothes, and so on.

3.2 Physical and Chemical Parameters of Water

Physical parameters observed during the study were parameters of temperature, brightness, depth, current, and substrate type. The chemical parameters observed during the study were the parameters of the degree of acidity (pH), DO, and salinity. The measurement results can be seen in Table 4. The substrate parameters during the study can be seen in Table 5.

The water temperature in the pond irrigation channels in Legonkulon ranges from 30 – 33,30 ˚C. Station 1 has an average temperature of 30,27 ± 0,25 ˚C which is the lowest average temperature value, and station 4 has an average temperature of 32,63 ± 0,76 ˚C which is the highest average value. Overall, the water temperature in the pond irrigation channels is still at the optimal temperature value for macrozoobenthos growth, which ranges from 25 - 35 ºC [14]. However, the water temperature in the pond irrigation channel exceeds the maximum limit of class III water quality standards stipulated in Government Regulation of the Republic of Indonesia No. 82 of 2001, so that the water in the pond irrigation channel is a source of water for cultivation activities is deemed not good enough.

Table 1. The Average Value of Macrozoobenthos diversity index in pond irrigation channels

Station	Diversity Index	Category
1	2.12	Moderate Diversity [13]
2	1.57	Moderate Diversity
3	3.01	Moderate Diversity
4	1.49	Moderate Diversity

Table 2. The Average Value of Macrozoobenthos uniformity index in pond irrigation channels

Station	Uniformity Index	Category
1	0.67	Medium Uniformity
2	0.56	Medium Uniformity
3	0.81	High Uniformity
4	0.43	Low Uniformity

Table 3. Abundance value of Macrozoobenthos at each station

Species	Station			
	1	**2**	**3**	**4**
Gastropods Class				
Filopaludina javanica	158	69		
Pomacea canaliculata	8	19		
Melanoides tuberculata	16			
Melanoides maculata	24	1		
Terebia granifera	28	134		
Bythinia truncatum	49	10		
Melanoides riquerti	7	2		
Nassarius stolatus			2	2
Thais tissoti			1	
Cerithidea cingulata			10	120
Telescopium telescopium			1	6
Nassaria pusilla			1	2
Murex trapa			1	
Cymatium cingulatum			1	
Hemifusus sp			1	
Cerithidea weyersi				1
Cerithidea quadrata				4
Dostia violacea				1
Bivalvia Class				
Pilsbryoconcha exilis	4			
Mytilus pictus	1	1		
Placuna placenta			1	
Perna viridis			5	
Saccostrea cucullata			7	
Crystospira ventri				1
Pholas orientalis				1
Hexanauplia Class				
Balanus balanoides			10	36
Malanostraca Class				
Pagurus acadianus			1	
Clitellata Class				
Hirudinaria sp				1
Abundance	295	235	40	175

The temperature difference in the pond irrigation channel in Legonkulon was caused by differences in sample measurement times. The temperature at station 1 has a lower average temperature compared to other stations, this is because the time for measuring water samples taken in the morning is different from stations 2, 3, and 4 which are carried out during the day. Water temperature variations at the four research stations are influenced by the time of measurement because the intensity of sunlight entering the waters in the morning is lower than when measuring waters during the day which have high sunlight intensity. The intensity of sunlight, the exchange of temperature between water and air, geographic altitude, and the presence of trees growing on the banks of rivers are all factors that cause differences in the results of temperature measurements at each station [15].

The current speed of each observation station is different. The highest current velocity was obtained at station 1 with an average of 0,31 ± 0,35 m/s, while the lowest current velocity was obtained at station 2 with an average of 0,07 ± 0,04 m/s Table 4. Waters are categorized as waters with very fast currents if the current speed is > 1 m/s, fast currents are 0,5 - 1 m/s, moderate currents are 0,25 – 0,5 m/s, slow current if 0,1 – 0,5 m/s, and the current is very slow, 0,1 – 0,25 m / s [16]. Based on this category, station 1 is classified as waters with moderate currents, stations 2, 3, and 4 are classified as waters with very slow currents.

Table 4. Average value of physical and chemical parameters

Station Parameters		**1**	**2**	**3**	**4**	*** quality standards**
Temperature (˚C)	Range	30-30,5	30,6-32	31,2-33,2	31,8-33,3	Deviation 3
	Average	30,27 ±0,25	31,30 ±0,70	32,33 ±1,03	32,63 ±0,76	
Current (m/s)	Range	0,1-0,71	0,03-0,1	0,05-0,1	0,03-0,25	-
	Average	0,31 ±0,35	0,07 ±0,04	0,08 ±0,03	0,12 ±0,12	
Depth (meter)	Range	0,42-0,73	0,52-0,62	0,3-0,67	0,25-0,57	-
	Average	0,57 ±0,16	0,59 ±0,06	0,46 ±0,27	0,44 ±0,17	
Water Transparency (meter)	Range	0,32-0,37	0,16-0,41	0,3-0,38	0,19-0,38	-
	Average	0,35 ±0,03	0,31 ±0,13	0,33 ±0,05	0,28 ±0,09	
Salinity(‰)	Range	17-20	20-23	33-38	32-34	-
	Average	18,67 ±1,53	21,33 ±1,53	36,00 ±2,65	33,33 ±1,15	
pH	Range	6,92-7,11	6,84-6,9	6,7-6,97	6,93-7,34	6 – 9
	Average	6,99 ±0,11	7,03 ±0,28	6,81 ±0,14	7,16 ±0,21	
DO (mg/L)	Range	6,4-8,0	6,5-7,0	4,2-5,3	6,2-6,8	3
	Average	7,33 ±0,83	6,67 ±0,29	4,37 ±0,86	6,5 ±0,30	

Information: * *Government Regulation of the Republic of Indonesia No. 82 of 2001 class III*

The abundance of macrozoobenthos at station 1 is higher than stations 2, 3, and 4 because station 1 has moderate currents. Bentos prefers moderate currents because it can carry the intake of organic material as food to support its survival, compared to strong and weak currents which make it difficult for bentos to get their food [17].

The average depth value at station 4 is 0,44 ± 0,17 meters. This value is considered to be the shallowest among the other stations because station 4 is a mangrove forest land that has a thicker pile of sediment compared to other stations. Station 2 has an average depth of the deepest among other stations, is 0,59 ± 0,06 meters, while station 1 has an average depth of 0,57 ± 0,16 meters, and station 3 has an average depth of 0,46. ± 0,27 meters.

The depth of water affects the number of species, individuals, and distribution patterns or the distribution of macrozoobenthos [18]. Macrozoobenthos that live in shallow waters tend to have a higher diversity of species compared to deep waters. This is by the results of the research found that station 4 with a shallow depth has a higher diversity of species, compared to station 2 with the deepest water depth which has a lower diversity of species.

The water transparency obtained in this research ranges from 0,16 to 0,39 meters with different average transparency at each station. The lowest average water transparency was found at station 4, namely 0,28 ± 0,09 meters or 28 cm, while the highest water transparency was found at station 1, namely 0,35 ± 0,03 meters or 35 cm Table 4. According to Sulaeman [15], waters with low transparency cause inhibition of the penetration of sunlight into the waters so that the photosynthesis process of algae and microphytes does not take place properly. Indirectly, transparency can affect macrozoobenthos life because algae and macrophytes are a food source for macrozoobenthos [19].

Dissolved oxygen values in the pond irrigation channels in Legonkulon ranged from 4,2 - 8 mg / L. The lowest average DO value was at station 3, namely 4,3 ± 0,86 mg / L and the highest average DO value was at station 1, namely 7,3 ± 0,83 mg/L Table 4. One of the factors that influence DO levels in river waters is the level of hardness of water flows or currents [20]. Station 1 has a moderate current with the highest average value of the four stations so that the DO concentration becomes high. Meanwhile, station 3 has a very slow current so the DO is low.

Based on research results, the value of dissolved oxygen in pond irrigation channels is still suitable for macrozoobenthos survival because the optimum DO for benthic growth and activity is 4,1 – 6,6 mg/L [8]. The pond irrigation channel in Legonkulon has the appropriate oxygen concentration because it meets the minimum requirement for dissolved oxygen for class III water quality standards in Government Regulation of the Republic of Indonesia No. 82 of 2001, namely 3 mg/L so that the water of the pond irrigation can be used as a source of water in cultivation activities.

In general, the average pH value in the pond irrigation channels in Legonkulon at each station is at neutral pH. Based on Government Regulation of the Republic of Indonesia No. 82 of 2001 on average at all observation stations meet the quality standards of class III water quality which requires a pH range of 6-9. Aquatic biota such as macrozoobenthos prefers a pH range of 7 – 8,5 so that if pH values 6 – 6,5 can cause a decrease in macrozoobenthos diversity [7]. The optimum pH will support the survival of aquatic organisms, but if the pH of the waters is too high or too low, it will affect the survival of aquatic organisms [6].

The salinity values in the pond irrigation channels in Legonkulon ranged from 17 - 38 ‰. The lowest average salinity value is obtained at station 1 because the location of the station has a greater influence from freshwater than other stations. Station 1 with an average salinity of 18,67 ± 1,53 ‰ is a freshwater river flow that is used to irrigate the surrounding community rice fields. The highest average salinity value was obtained at observation station 3 at 36,00 ± 2,65 ‰ Table 4, this is because station 3 has a high temperature. Increased salinity due to high water evaporation causes the salt content to settle [21].

The results showed that the average salinity value of each observation station was still suitable for the survival of macrozoobenthos. The salinity range for the survival of macrozoobenthos ranges from 20 - 36 ‰ [22]. Salinity changes will affect the osmotic pressure in the organism's body. High salinity causes a large osmotic pressure, so the organism must have the ability to adapt to changes in saline.

Table 5. Fraction value and substrate type at each observation station

Station	Fraction Parameter			Substrate Type
	Sand	Clay	Dust	
1	13%	36%	51%	Dusty Clay
2	35%	38%	27%	Clayey Clay
3	5%	21%	74%	Dusty Loam
4	9%	33%	58%	Dusty Loam

3.3 Substrate Type

The substrate type consists of several fractions, namely sand, clay, and dust (mud). The substrate type is determined by measuring the composition of the fraction. The results of the substrate texture composition analysis showed that the highest percentage fraction at each station was dust. The percentage of dust fraction at station 3 was 74% while the lowest dust fraction was at station 2 at 27%, station 1 at 51%, and station 4 at 58%. The substrate composition is used in determining the type of substrate using the Millar triangle method. The analysis showed that the substrate in the pond irrigation channel in Legonkulon could be categorized into 3 categories, including dusty clay, clayey clay, dusty loam.

The basic substrate is a major factor influencing the abundance and distribution of macrozoobenthos [22]. The substrate is a habitat for macrozoobenthos to attach, creep, or walk. The bottom substrate of the waters acts as a provider of organic material which is a source of food. Macrozoobenthos tend to prefer the dusty clay substrate type compared to the sandy substrate because of the ability of sludge or dust sediment to store more organic matter than sandy substrates. The sludge substrate has denser pores so that organic material settles more easily, in contrast to sandy substrates which have larger particles and pores, which make the organic matter more easily carried away [23]. Station 1, Station 3, and Station 4 tend to contain a low sand fraction compared to station 2, so it can be seen from the abundance and diversity of macrozoobenthos at stations 1, 3, and 4 which are higher than station 2.

4. CONCLUSION

Based on the research results, it can be concluded that in general the water quality in the pond irrigation channel in Legonkulon, Subang Regency, is in the medium polluted category. The macrozoobenthos diversity index of each station is in the medium category 1.0 <H '<3.322. The uniformity value of the four stations ranges from 0.43 to 0.81 with the low - high category. The highest uniformity index was found at station 3, and the lowest uniformity index was at station 4, while at station 1 and station 2 had a moderate uniformity index.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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