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Study of Gastropod Community Structure After Development of Tourism Activities on the Senjoyo River

Kajian Struktur Komunitas Gastropoda Pasca Pengembangan Aktivitas Pariwisata di Sungai Senjoyo

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ABSTRACT

It is thought that the development of the Senjoyo River as a tourist attraction in Semarang Regency will cause changes to the natural ecosystem in the area, one of which is changing the structure of the existing gastropod community. This research is a quantitative analysis research using a survey method that aims to examine the structure of the gastropod community after the development of tourism activities on the Senjoyo River. Gastropod samples were taken from 10 different observation stations along the Senjoyo River, which are located at 7˚22'23"S and 110˚31'37"E. Observation station locations were determined by the purposive random sampling method, based on tourism activity density. The result showed types of gastropods that were found in the Senjoyo River namely, *Sulcospira testudinaria, Tarebia granifera, Brotia costula, Thiara scraba*, and *Melanoides tuberculata* with clustered distribution patterns (Id>1). Statistical analysis showed that location affected gastropod abundance (Asymp. Sig of 0.043), with the highest abundance found at station seven (45,11 individuals/m2). So station seven, with sandy and muddy substrate conditions, moderate current speed (0.257 m/s), and rarely found human activity, is the most suitable location to support the survival of gastropods in the Senjoyo River. Furthermore, the gastropod community structure indicates environmental changes at observation stations nine and ten, the locations where the most activities and construction of tourism facilities were found. That was indicated by the low diversity (H'= 0.00-0.01) and evenness (E = 0.00) index of gastropods, and there is dominance by *Sulcospira testudinaria* (C= 0.98-1.00).

Keywords: Gastropods, *Sulcospira testudinaria*, Senjoyo River, Tourism

ABSTRAK

Pengembangan Sungai Senjoyo sebagai objek wisata di Kabupaten Semarang diperkirakan akan menyebabkan perubahan ekosistem alam di kawasan tersebut, salah satunya mengubah struktur komunitas gastropoda yang ada. Penelitian ini merupakan penelitian analisis kuantitatif dengan menggunakan metode survei yang bertujuan untuk mengetahui struktur komunitas gastropoda pasca berkembangnya kegiatan wisata di Sungai Senjoyo. Sampel gastropoda diambil dari 10 stasiun pengamatan berbeda di sepanjang Sungai Senjoyo yang terletak pada 7˚22'23"LS dan 110˚31'37"BT. Lokasi stasiun pengamatan ditentukan dengan metode *purposive random sampling*, berdasarkan kepadatan kegiatan pariwisata. Hasil penelitian menunjukkan jenis gastropoda yang ditemukan di Sungai Senjoyo yaitu *Sulcospira testudinaria, Tarebia granifera, Brotia costula, Thiara scraba*, dan *Melanoides tuberculata* dengan pola sebaran mengelompok (Id>1). Analisis statistik menunjukkan bahwa lokasi berpengaruh terhadap kelimpahan gastropoda (*Asymp. Sig* sebesar 0,043), dengan kelimpahan tertinggi terdapat pada stasiun tujuh (45,11 individu/m^2). Sehingga stasiun ketujuh dengan kondisi substrat berpasir dan berlumpur, kecepatan arus sedang (0,257 m/s), dan jarang ditemukan aktivitas manusia merupakan lokasi yang paling cocok untuk mendukung kelangsungan hidup gastropoda di Sungai Senjoyo. Selain itu, struktur komunitas gastropoda menunjukkan perubahan lingkungan pada stasiun pengamatan sembilan dan sepuluh, lokasi yang paling banyak ditemukan aktivitas dan pembangunan fasilitas pariwisata. Hal ini ditunjukkan dengan rendahnya indeks keanekaragaman (H'=0,00-0,01) dan kemerataan (E=0,00) gastropoda, serta adanya dominansi *Sulcospira testudinaria* (C=0,98-1,00).

Kata Kunci: Gastropoda, *Sulcospira testudinaria*, Sungai Senjoyo, Pariwisata

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INTRODUCTION

The Senjoyo River is one of the rivers in Semarang Regency that has an essential role as a source of irrigation water. The Senjoyo River irrigation area has a coverage area of 2,335 ha with a maximum irrigation discharge of 3.28 m^3/s, which covers the area of Semarang Regency and Salatiga City (Kurnianto and Sutopo, 2020). There are ten irrigation areas (DI) originating from springs and the Senjoyo River, namely DI Isep-Isep with an irrigation area of 55 ha, DI Watu Kodok with an irrigation area of 32 ha, DI Senjoyo with an irrigation area of 1828 ha, DI Grenjeng with an irrigation area of 753 ha, DI Belon with an irrigation area of 280 ha, DI Sucen with an irrigation area of 673 ha, DI Cepoko with an irrigation area of 621 ha, DI Nyamat with an irrigation area of 97 ha, DI Aji Getas with an irrigation area of 119 ha, and DI Gendor with an irrigation area of 116 ha (Rahmawati, 2007). This river is also used as a tourist attraction because it is located in the area around seven important springs in Semarang Regency known as Umbul Senjoyo. Tourism on the Senjoyo River is mass tourism, which has been developing since 2015 with the existence of the Pokdawis "Senjoyo Village". Until now, tourism on the Senjoyo River has been developing very rapidly, as evidenced by the construction of various tourism facilities such as gazebos, water games, toilets, and interesting photo spots.

The development of tourism is thought to trigger changes in the condition of the natural ecosystem, which leads to damage to the aquatic environment in the Senjoyo River. Research on the sustainability index of Senjoyo Spring shows that the average sustainability score on the environmental aspect (ecological dimension) is in the moderately sustainable category, which is 54.78 (Reza et al., 2021). A sustainability index is an approach to finding out how sustainable an area or activity is, one of which is from an environmental perspective. An area or activity with a high sustainability index (75.01-100.00) is included in the sustainable category and shows that environmental management has been carried out properly and sustainably (Fitrianto et al., 2021). Furthermore, research by Reza et al. (2021) concluded that tourism management which is dominated by mass tourism activities is the main factor that causes the region to be in the fairly sustainable category. This can be seen from the highest leverage score owned by the attributes of protecting rivers and springs (3.50) and tourism activities (3.20). Therefore, both are the two most sensitive attributes to support the sustainability of the Senjoyo Spring. Based on these various things, further studies regarding the impact of tourism activities on changes in the environment of the Senjoyo River need to be carried out.

One of the organisms that are sensitive to environmental changes in river ecosystems is the gastropod. Gastropods are macrozoobenthos, which play an important role in the food chain in freshwater ecosystems. Most gastropods eat dendrites and fallen leaf litter and circulate substances suspended in the water to get food, such as moss or algae (Andriati and Rizal, 2020). Gastropods also have very slow movements and are very sensitive to chemical pollutants. In addition, gastropods have the ability in their bodies to accumulate chemical compounds in cases of heavy metal pollution (Ranjan and Babu, 2016). Gastropods usually live sedentary on the substrate, are attached to rocks or plants, have a long life span, and have an abundance and wide geographical distribution (Silaen et al., 2013). Not only that, but gastropods also have low mobility and relatively large body sizes to facilitate identification (Gupta and Singh, 2011). Based on these characteristics, gastropods can act as bioindicators in aquatic ecosystems to assess environmental changes and pollution. Several studies have used gastropods as bioindicators. Mardika et al. (2020) studied the quality of the waters in the Nogosari River through the diversity index in the river. The results of this study showed that the average gastropod diversity index in the Nogosari River was 2.09 Ind/m^2, so it was in the moderately polluted category. Kawuri et al. (2012) also conducted a study of the Seketak River, which was polluted by household waste through gastropod bioindicators. The results showed that the Seketak River at Station II was included in the heavily polluted category. This is based on the diversity index (0.83), individual abundance (273 ind/m^2), and evenness index (0.40).

In this research, a study was conducted on the structure of the gastropod community after the development of tourism activities on the Senjoyo River. This study is an approach that aims to determine whether or not there is a change in the condition of the aquatic environment that affects the structure of the gastropod community in the Senjoyo River. Through this research, the diversity and structure of the gastropod community in the Senjoyo River after the development of tourism activities can be identified. Indirectly, the water quality of the Senjoyo River can also be estimated due to the ability of gastropods to act as bioindicators. Information from the results of this study can be useful as a basis for consideration in determining policies related to tourism management on the Senjoyo River and the surrounding area.

MATERIALS AND METHOD

Method

This research is a quantitative analysis with a survey method. Gastropod samples were taken from 10 different observation stations along the Senjoyo River, which are located at 7˚22'23"S and 110˚31'37"E and are located at an altitude of 694 m above sea level. There are 10 observation stations, which are the locations for sampling gastropods and water samples in this study (Figure 1). The location of the observation station was determined by the purposive random sampling method, using the criteria of tourism activity density as the basis for the determination.

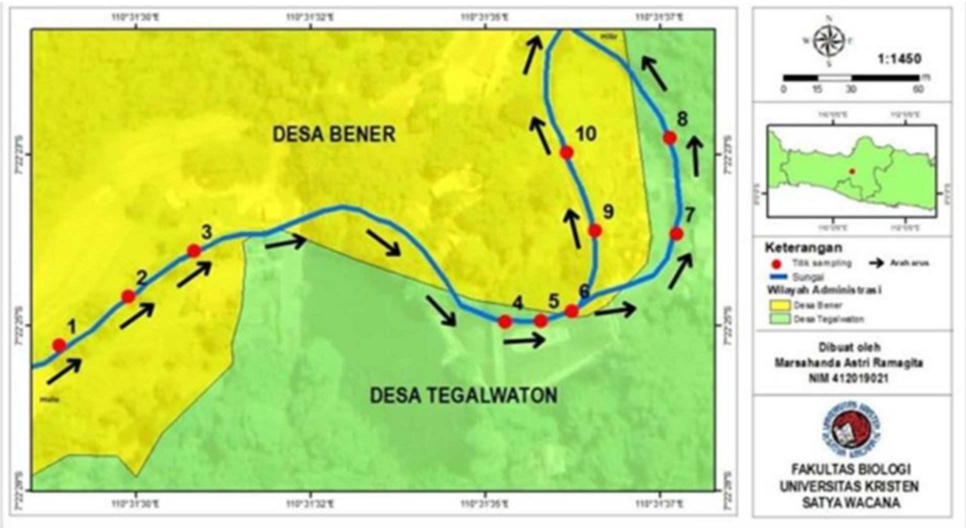

Figure 1. Map of sampling locations

Gastropod samples were taken by hand in three repetitions, with an interval of two weeks between each repetition. The samples were then identified based on the book Freshwater Snails of Java Island: Molluscs, Gastropods (Marwoto and Isnaningsih, 2012), and Invertebrates of Streams and Rivers (Quigley, 1977). Data on the number of genera and the number of individuals in one genus at each observation station were collected to calculate various parameters, namely the Shannon-Wiener abundance index, evenness index, Shannon-Wiener diversity index, Simpson dominance index, and Morisita's dispersion index (Table 1). Water quality at each observation station was also analyzed through the parameters of temperature, current velocity, BOD (Biological Oxygen Demand), phosphate, and nitrate.

Table 1. Formulas used in calculating various research parameters

Formula	Information	References
Gastropod abundance Cumulative abundance $A = \frac{X_i}{N_i}$	Cumulative abundance A = population abundance (ind/m^2) N_i = the number of individuals to-i X_i = wide (m^2)	Saputra et al. 2018; Anggraini, 2019
Relative abundance $KR = \frac{X_i}{N} \times 100\%$	Relative abundance KR = relative abundance (%) N_i = the number of individuals to-i N = the total number of individuals	
Shannon-Weiner Diversity Index $H' = -\sum_{i=1}^{S}(pi)(lnpi)$	H' = Shannon-Weiner diversity index S = number of species P_i = the number of individuals to-i	Fadhilah et al. 2013
Evenness Index: $E = \frac{H'}{H_{maks}}$	E = Evenness index H' = the value of the species diversity index	Anggara et al. 2017
Dominance Index: $C = \frac{N_i}{N}$	C = Dominance index N_i = the number of individuals to-i N = the total number of individuals	Sutrisna et al. 2018
Morisita's Dispersion Index $Id = n\frac{\sum x^2 - N}{N(N-1)}$	Id = Morisita's dispersion index n = the total number of individuals in the plot N = the total number of individuals in the n plot Σx^2 = the sum of the squares of all individuals in the plot	Widiyanti et al. 2020

Data analysis

Data analysis was carried out using SPSS (Statistical Product and Service Solutions) version 23 to see whether there were significant differences in gastropod abundance, temperature, current velocity, BOD, phosphate, and nitrate between stations. The index parameters of diversity, evenness, and dominance were analyzed descriptively based on the criteria for each of these indices (Table 1). The correlation between environmental parameters as independent variables and gastropod community structure parameters (diversity, evenness, dominance, and abundance) as dependent parameters was analyzed using the CCA (Canonical Correspondence Analysis) method using the PAST 4.03 application.

RESULT AND DISCUSSION

The composition of the gastropods found at the 10 observation stations on the Senjoyo River consisted of five species belonging to two different families. These species include *Sulcospira testudinaria*, *Tarebia granifera*, *Brotia costula*, *Thiara scraba*, and *Melanoides tuberculata*. Most of the gastropod species found had brown shells. However, the *Thiara scraba* species has a lighter shell color than the other four species. In the species *Brotia costula* and *Melanoides tuberculata*, there are light brown and dark brown blaster patterns. The shell shape of *Sulcospira testudinaria* and *Melanoides tuberculata* is oval, while that of *Tarebia granifera*, *Brotia costula*, and *Thiara scraba* is more rounded. On the surface of the *Tarebia granifera* shell, there are nodules. Whereas the surface of the *Melanoides tuberculata* shell has a jagged texture. Meanwhile, *Sulcospira testudinaria*, *Brotia costula*, and *Thiara scraba* have smoother shell surfaces. *Sulcospira testudinaria* which was found to have a larger size than other types of gastropods (Figure 2).

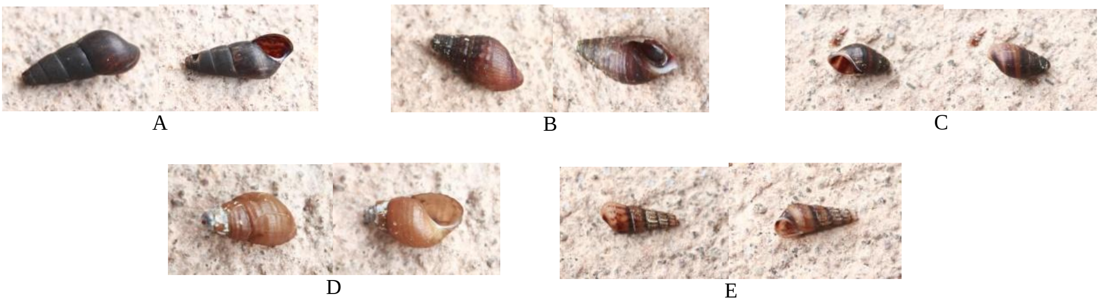

Figure 2. Gastropod diversity in the Senjoyo River (A: *Sulcospira testudinaria*, B: *Tarebia granifera*, C: *Brotia costula*, D: *Thiara scraba*, and E: *Melanoides tuberculata*)

All species of gastropods found in the Senjoyo River have operculum, with various shapes (Figure 3). *Sulcospira testudinaria* has a multispiral/polygynous (spiral structures that are closely spaced with a large number) shape of operculum, *Tarebia granifera* has paucispiral or oligogyrous (slightly spiral) operculum, *Brotia costula* operculum is concentric in shape (core as center or subcentral), whereas *Thiara scraba* has an embedded or flattened operculum (growing only on one side with a marginal nucleus). The operculum is a cover on the aperture (shell opening) of gastropods that is formed from a calcareous substance. The growth of the operculum follows the growth of the shell so that its size is always proportional to the aperture. The operculum is attached to the terminal end of the columellar muscle, with the ridge of the opercular plate pointing toward the upper surface of the hind leg. In nature, not all types of gastropods have an operculum. Operculum plays a role in the survival of gastropods by avoiding drought or loss of water content during dry weather as well as providing self-protection tools from predators (Arbi, 2013). According to Satriarti et al. (2019), gastropods that have an operculum can survive in heavily polluted water conditions because they can close their shells when water conditions are outside their tolerance range.

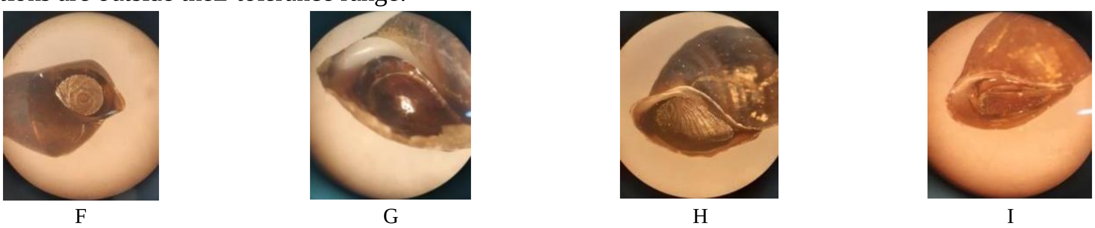

Figure 3. Gastropod operculum shape in Senjoyo River
(F: *Sulcospira testudinaria*, G: *Tarebia granifera*, H: *Brotia costula*, I: *Thiara scraba*)

Gastropod distribution patterns in the Senjoyo River were analyzed by morisita's dispersion index (Id). The result showed that all species of gastropods in all observation stations were close to or greater than 1, namely between 0.98-3 (Table 2.). According to Mardatila et al. (2016), the value of Id>1 indicates a clustered distribution pattern, Id=1 indicates a random distribution pattern, and Id<1 indicates a uniform distribution pattern. Therefore, the gastropods in the Senjoyo River have a clustered distribution pattern. In nature, clustered distribution patterns are more common than uniform distribution patterns. This pattern can indicate the condition of the availability of resources that are not evenly distributed, as well as the presence of stress in certain parts of an area. Nevertheless, the pattern of distribution in clusters can also be the result of natural interactions between the environment and species to achieve effective survival, so they do not always show negative environmental conditions. Gastropods tend to cluster in areas where food availability and environmental conditions are suitable for population growth and development. The results of research by Zulkifli and Setiawan (2011) show that gastropods tend to cluster in locations that have substrates with high levels of organic matter, which is food for gastropods. In addition, organisms that have low mobility such as gastropods usually tend to live in groups (Susanti et al., 2021).

Table 2. Gastropod morisita's dispersion index in the Senjoyo River

Species	Observation Station									
	1	2	3	4	5	6	7	8	9	10
Sulcospira testudinaria	1,04	1,14	1,71	1,19	1,52	1,06	1,26	2,64	2,55	1,06
Tarebia granifera	1,53	0,98	1,40	1,44	-	2,12	1,48	1,29	-	-
Brotia costula	2,02	3	3	1,57	1,48	2,88	1,22	1,77	-	1
Mieniplotia scraba	-	-	-	3	1,47	3	3	3	-	-
Melanoides tuberculata	-	-	-	-	-	-	-	-	-	-

Results of statistical analysis using the Kruskal-Wallis test showed that location affected the gastropod abundance parameter (Asymp. Sig of 0.043). When compared between stations, seems that the gastropod population in the Senjoyo River tends to be most clustered at station seven (Figure 4). Observation station seven has the highest abundance of gastropods, that is 45.11 ind/m^2 (Isnaningsih and Listiawan, 2016). This station has sandy and muddy substrate conditions, moderate current speed (0.257 m/s), and rarely found human activity. This station is in a location that is still natural, and there is no tourism activity. Isnaningsih and Listiawan (2016) state that in general, gastropods tend to live in rocky, mud, or sand substrates, which are stagnant areas with calm to moderate currents. Therefore, the high abundance of gastropods at station seven is due to the suitable substrate, the water conditions, which tend to be stagnant with moderate currents, and the fact that there are not many disturbances in the form of human activities. Station seven in this study is the most suitable location to support the survival of gastropods. In addition, station ten also showed a high abundance of gastropods (31.11 individuals/m^2). Nevertheless, unlike in station seven where the abundance consisted of four species of gastropods, the high abundance of gastropods at station ten was due to the dominance of the species *Sulcospira testudinaria*.

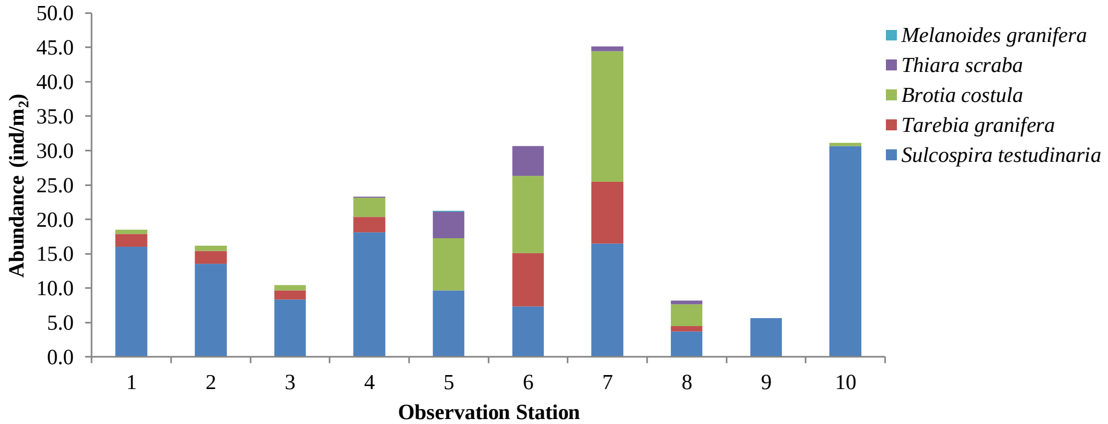

Figure 4. The abundance of gastropods in the Senjoyo River

The gastropod community structure in Senjoyo River shows that the diversity index (H') of observation stations 1, 2, 3, 4, 9, and 10 belongs to the low category (ranging from 0.00-0.72), while observation stations 5, 6, 7, and 8 in moderate category (ranging from 1.06 to 1.33). According to Hamidy (2010), the value of H'<1.0 is included in the low category, the value of 1 <H' ≤ 3.322 is included in the moderate category, and the value of H'> 3.322 is included in the high category. A community has a high diversity index if its structure is composed of many types of organisms (species). Conversely, a community that is only composed of a few species will show a low diversity index because there tend to be species that dominate (Indriyanto, 2015).

The observation results through the diversity index parameter are validated by the results of the dominance index parameter (C) and evenness index (E). Merly and Elviana (2017) stated that the value of the diversity index is directly proportional to the evenness index but inversely proportional to the dominance index value. The results of this study are in line with this statement. Observation stations with a moderate diversity index (range 1,06-1,33) also showed a high evenness index (range 0,69-0,83), but the dominance index was in the low category (range 0,28-0,37), and vice versa.

Stations with a moderate diversity index, a high evenness index, and a low dominance index indicate that environmental conditions are still good enough to support the stability of the gastropod community. On the other hand, stations with a low diversity index, a low evenness index, and a high dominance index indicate that the environmental conditions at that location are putting pressure on the gastropod community. This is in line with the statement of Purnama et al. (2011), who mentioned that diversity in the moderate category shows fairly good organism productivity, fairly balanced ecosystem conditions, and moderate ecological pressure. Therefore, it was concluded that the environmental conditions that support the stability of the gastropod community are stations five to eight. The environmental conditions at stations one to four do not support the stability of the gastropod community. Meanwhile, stations nine and ten were locations with the least supportive environmental conditions and showed pressure on gastropod communities (Table 3).

Table 3. Gastropod diversity, dominance, and evenness index values in the Senjoyo River

Observation Station	H’	Category (Hamidy, 2010)	C	Category (Kasry et al., 2012)	E	Category (Anggara et al., 2017)	Conclusion
1	0,57	Low	0,7	One dominates	0,41	Medium	Unstable community
2	0,59	Low	0,67	One dominates	0,43	Medium	Unstable community
3	0,68	Low	0,63	One dominates	0,49	Medium	Unstable community
4	0,72	Low	0,63	One dominates	0,45	Medium	Unstable community
5	1,06	Medium	0,37	Nothing dominates	0,77	High	Stable community
6	1,33	Medium	0,28	Nothing dominates	0,83	High	Stable community
7	1,12	Medium	0,35	Nothing dominates	0,69	High	Stable community
8	1,13	Medium	0,37	Nothing dominates	0,82	High	Stable community
9	0,00	Low	1,00	One dominates	0,00	Low	Depressed community
10	0,01	Low	0,98	One dominates	0,00	Low	Depressed community

Note: H’ (diversity); C (dominance); E (evenness)

Stations five and six in this study are tourism areas on the Senjoyo River. However, tourism activities at these stations are relatively less dense compared to observation stations nine and ten. So, environmental conditions tend to still support the gastropod community because they have not experienced much disturbance or anthropogenic contamination. Observation stations seven and eight are areas that are still natural and are not used as tourism locations (Figure 5). This can be seen from the absence of tourist facilities at both stations. The environmental conditions at both stations are also less supportive of tourism activities due to the swift, deep currents, and the more turbid water. This location supports the stability of the gastropod community the most, as seen from the diversity index, which is relatively higher than other observation stations. In addition, the substrate at stations five and eight is sandy, slightly rocky, and muddy. Gastropods tend to prefer substrates that have a solid surface so that periphytic organisms can grow, which becomes food for gastropods. This presumption is strengthened by the study of Handayani et al. (2021), which showed that the highest diversity of gastropods in the Bahowo mangrove ecotourism area was found in locations that have a solid substrate; namely transect 1 (coral reefs), compared to transect 2 (seagrass beds) and transect 3 (mangrove).

Observation stations nine and ten in this study are the main locations for mass tourism along the Senjoyo River. This can be seen from the development of many tourism facilities, such as huts and ball bathing activities. Both stations also have environmental conditions that support tourism activities, such as calm, shallow currents, and clear water. Hence, visitors tend to bathe, swim, and even wash at that location. This high tourism activity is suspected of putting pressure on the gastropod community in those locations. This is in line with the study results of Zulfa (2022) that show the gastropod diversity at observation station II at Lorotan Waterfall is in the low category (0.429) due to pollution from tourism activities such as playing, bathing, and washing which causes high Chemical Oxygen Demand (COD) at this observation station.

Figure 5. Condition of observation stations one to ten in Senjoyo River

Certain environmental pressure on the structure of the gastropod community at stations nine and ten also can be seen from the presence of dominance of the *Sulcospira testudinaria* species. Dominance occurs because environmental conditions are very favorable for supporting the growth of certain species (Ridwan et al., 2016). A high index of gastropod dominance in an area can also indicate a polluted habitat condition so that only certain species are tolerant and can dominate. According to Arumsari and Adharini (2021), *Sulcospira testudinaria* is a gastropod that is spread across Java and has a high level of tolerance for pollution in its habitat. Suwignyo et al. (2005) stated that *Sulcospira testudinaria* is a freshwater gastropod classified as a suspension feeder, having long filamentous gills to trap plankton or suspension carried by water currents. Gastropods which are classified as suspension feeders are thought to be an alternative for reducing total organic matter levels in waters. This statement is justified by Lailiyah et al. (2021) research which showed that the organic matter content in the live media of *Sulcospira testudinaria* was reduced by 87% within 8 hours (from 72.48 mg/L to 9.35 mg/L) because it was used as a food source by these gastropods. Therefore, the dominance of *Sulcospira testudinaria* at stations nine and ten indicates that organic pollution has occurred at these stations

Besides that, the results of water quality analysis in the Senjoyo River through chemical and physical parameters show that: (1) the temperature at ten observation stations ranged from 22.60-25.93˚C, (2) the current speed was between 0.148-0.449 m/s, (3) BOD was 1.16-4.53 mg/L, (4) phosphates ranged from 0.03-0.14 mg/L, and (5) nitrates ranged from 6.86-9.84 mg/L (Table 4).

Table 4. Physical and chemical water quality at each observation station on the Senjoyo River

Parameters	Unit	Observation Station									
		1	2	3	4	5	6	7	8	9	10
Temperature	(˚C)	24,87	25,93	25,67	24,57	24,33	24,00	23,17	23,17	22,80	22,60
Flow rate	(m/s)	0,270	0,322	0,322	0,270	0,389	0,449	0,257	0,471	0,148	0,325
BOD	(mg/L)	1,16	2,08	2,28	2,35	2,31	2,52	4,53	4,32	3,31	2,92
Phosphate	(mg/L)	0,05	0,04	0,03	0,20	0,11	0,10	0,12	0,12	0,14	0,13
Nitrate	(mg/L)	6,86	7,69	7,84	8,28	8,62	9,06	9,25	9,40	9,67	9,84

The statistical analysis, and ANOVA test, it is known that location affected the temperature (Asymp. Sig of 0.005), current velocity (Sig of 0.026), BOD (Sig of 0.008), phosphate (Asymp. Sig of 0.019), and nitrate (Sig of 0.000). The range of temperature measurement results in this study is sufficiently optimal for the survival of gastropods. This is in line with the statement of Fadhilah et al. (2013) which states that the growth of gastropods is affected by optimal temperatures between 20-30˚C. The current speed in this study is included in the slow to moderate category. According to Koroy et al. (2017), current speed consists of 4 categories, namely 0-0.17 m/s including slow currents, 0.17-0.34 m/s medium currents, fast currents ranging from 0.34-0.51 m /s, and >0.51 m/s including very fast currents. The results of measuring current velocity are quite optimal for gastropod habitats because the distribution of sediment formation, which is dominated by clay or mud in gastropod habitats, is strongly influenced by slow currents (Gultom et al., 2018).

The correlation between physical and chemical water quality (as independent variables) and gastropod community structure (as dependent variables) in Senjoyo River, then was analyzed using the CCA (Canonical Correspondence Analysis) method. The results showed that current velocity and temperature are the environmental variables that have the most correlation with the diversity and evenness of gastropods. This is by the statement of Hoffman et al. (2006) that current velocity can affect the distribution of gastropods. In addition, warmer temperatures correlate with the diversity and evenness of gastropods found in the Senjoyo River. According to Wantasen (2013), the higher the temperature of the water, the higher the diversity of gastropods found because temperature plays an important role in respiration and physiological processes. Besides that, gastropod abundance in this study was affected by all parameters at moderate intensity (Figure 6).

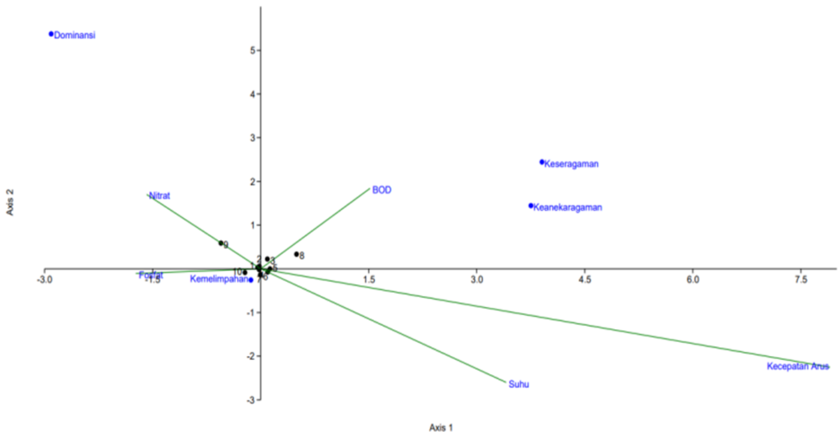

Figure 6. Scatter plot of CCA between environmental variables and gastropod community structure in Senjoyo River

CONCLUSION

Species of gastropods that were found in the Senjoyo River are *Sulcospira testudinaria*, *Tarebia granifera*, *Brotia costula*, *Thiara scraba*, and *Melanoides tuberculata* with a clustered distribution pattern. Gastropod community structure indicates an environmental change at observation stations nine and ten, namely the locations where the most activities and construction of tourism facilities were found. These environmental changes cause a low diversity and evenness index at the gastropod community structure and dominance of *Sulcospira testudinaria*

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