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RESEARCH ARTICLE

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Contribution of the mangrove ecosystem to the gastropod community at Pantai Bahagia Village, Muara Gembong, West Java

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Abstract

The Mangrove ecosystem of Muara Gembong has been under continuing stress by land occupation, land conversion, and abrasion. This research was aimed to reveal the mangrove and gastropods community structure circumstance. A contribution of the environmental factor was also assessed to evaluate the interaction among them and to track the changes of the ecosystem. This research was conducted by purposive sampling in 3 sampling sites, these were a full reforestation site (A), a central site, that existed by natural process (B), also a moderate reforestation site (C), with 3 sampling replication each site. About 4 mangrove species within the shoreline have been progressively important as a protective flood barrier and abrasion at Muara Gembong. The highest gastropod diversity was found in the B1 site, while the highest dominance was found in A2. The C2 site is the only site that showed us a uniform dispersion of gastropods when the other sites showed a clumped dispersion. It can be implied that the ecosystem has been gradually degraded. Eigen and loading value from Canonical Correspondence Analysis (CCA) revealed that a gastropod community was holistically affected by pH, basal area, canopy, substrate, and TDS. The community of gastropods was influenced 62.14% by pH, and 34.29% by basal area. While the highest dominance was found in A2. The C2 site is the only site that showed us a uniform dispersion of gastropods when the other sites showed a clumped dispersion. It can be implied that the ecosystem has been gradually degraded.

Keywords: Muara Gembong, mangrove, gastropod

Introduction

Muara Gembong Mangrove Forest, which is located on the North Coast of Java Island and directly adjacent to DKI Jakarta, has a relatively high level of degradation threat. Since being designated as a protected forest area by the Indonesian Minister of Agriculture in 1954 through Decree No. 92 / UM

/ 54[1], the Muara Gembong mangrove forest has continued to experience various pressures such as land occupation, land conversion, and land conversion / function. Most of the area has been converted into ponds, rice fields, gardens and even settlements. Meanwhile, the Indonesian Minister of Forestry issued Decree No. 475 / Menhut-II / 2005 concerning the Change of Status of the Ujung Krawang Protected Forest (Muara Gembong) covering an area of 5,170 hectares to become permanent production forest (HPT)[2]. Because of this policy, this area can be developed in accordance with the spatial planning of Bekasi Regency (Perda Kab. Bekasi No. 4/2007)[3]. This policy certainly has a direct or indirect impact on the condition of mangroves which have been damaged due to various pressures.

This policy causes disturbance and damage and narrowing of mangrove land which has an impact on decreasing the diversity of mangrove species[4]. The use of land around mangroves has significantly affected the sustainability of the mangrove ecosystem[5]. Changes in structure and composition have the potential to cause changes in other communities whose lives depend on the mangrove ecosystem such as mangrove gastropods.

The mangrove ecosystem in Muara Gembong experienced considerable degradation. In 2003, the area of the Muara Gembong mangrove forest decreased at a rate of 255.22 ha/year and the remaining area was only 386.21 ha[6]. This happens because the mangrove areas in Muara Gembong have been converted into ponds by the local community. Damage to the mangrove ecosystem has caused the rate of abrasion to increase and the abrasion problem that has occurred up to now requires proper countermeasures. In an effort to overcome this environmental problem, the damage that has occurred needs to be further evaluated.

Mangroves are very productive and useful ecosystems, such as the roots of mangrove vegetation which are the substrate for attaching various organisms, one of which is gastropods. Gastropods get nutrients from the surface of the sediment, the substrate from mangrove vegetation, so that the presence of mangroves affects the presence of gastropods. The purpose of this study was to determine preliminary data on the structure and composition of mangrove vegetation and mangrove gastropods and their relationship to environmental conditions studied in Pantai Bahagia Village, Bekasi Regency as a basis for evaluating changes that occur in the mangrove ecosystem. Scientific studies are carried out aimed at providing space for local conservation development. This study aims to determine the distribution of gastropods in the forest ecosystem and their effect on the condition of mangrove vegetation.

Materials and methods

Study area

The research location in the field is administratively located in Pantai Bahagia Village, Muara Gembong District, Bekasi Regency, West Java. This research was conducted from July to September 2020. Geographically, the research location is located in the north of Java Island (Figure 1). The research method used was a purposive sampling method based on the station group. The research location is known as an estuary coastal area. Substation A1: 5 ° 55'23.6 "South and 107 ° 01'30.4" East. Substation A2: 5 ° 55'34.5 "South and 107 ° 01'54.7" East. Substation B1: 5 ° 55'25.0 "South and 107 ° 02'07.1" East. Substation B2: 5 ° 55'26.2 "South and 107 ° 02'09.8" East. Substation C1: 5 ° 55'40.6 "South and 107 ° 02'18.4" East. Substation C2: 5 ° 55'40.1 "South and 107 ° 02'22.1" East.

Procedures

Taking Mangrove vegetation structure data for tree category dbh (diameter at breast height) ≥ 10 cm and height> 1.5 m taken from tree plots measuring 10 mx 10 m in the form of the number of mangrove stands and tree diameter in the plot. Sapling samples (saplings) were mangrove vegetation with dbh ≤ 10 and 1 m <height <1.5 m from the subplot of tillers measuring 5 mx 5 m. The seedling samples were mangrove vegetation with a height of <1 m in a subplot of 1 mx 1 m seedling. Each plot was repeated 3 times where each replication was 10 meters apart[7]. Tree category is measured at stem diameter at breast height by circling the circumference of the tree with a rope and converted to the formula for the circumference of a circle. The rod diameter is used for data type closure and relative type closure. Measurement of environmental factors in the field in the form of pH, temperature, salinity, TDS, and canopy cover using digital hardware. Sediment samples were collected and processed in the laboratory for the determination of substrate types by mechanical and hydrometric methods.

Gastropod community structure data collection was carried out with a plot of 1 mx 1 m with each station (substation) 3 replications. Samples were taken and observed using a luv or stereo microscope[7] in the IBCU Secretariat laboratory. Gastropod identification was using the Recent Fossil Indonesian Shell identification book[8].

Substrate sampling was carried out at each density. Analysis of substrate grain size was carried out by two methods, namely the mechanical (gravimetric) method to determine the percentage of coarse substrate fraction (d> 0.05 mm) and the hydrometric method to see the percentage of dust and clay grains. Mechanical method with the following work procedure, the substrate sample is rinsed with fresh water, then dried using an oven. After drying, cool the sample, then weigh the sample to be analyzed. Put the sample into the sieve net, then shake it with a shaker for ± 15 minutes. Separate the sieve based on the net size, then weigh the sieve results from each net size. Substrate samples that passed the 2 mm sieve were further analyzed using the hydrometric method[9].

Hydrometric method with the following work procedure, 100 grams of dry substrate sample is put into a beaker glass. Add 10 g of 0.01 N sodium oxalate solution and 5 g 0.02 N of sodium carbonate, then stir the mixture. If there are still lumps, add a solution of 0.01 N sodium oxalate and 5 grams of 0.02 N sodium carbonate until there is no clumping. Enter the sample into a 1000 ml cylindrical tube and add 1000 ml of distilled water, then stir. Let the mixture settle. After 7 minutes 44 seconds, take the substrate sample using a pipette at a depth of 10 cm as much as 20 ml, then put it in a petri dish that has been heated for 1 hour and the weight is also known. Oven dry for 2 hours, then cool in a desiccator. Once cool, weigh it with a digital scale. The final weight minus the weight of the empty petri dish is the sample weight of 0.002 mm (dust). After 2 hours 3 minutes, the sample is taken again with a pipette at a depth of 10 cm as much as 20 ml and then put into a petri dish. Furthermore, the sample in the petri dish was dried in an oven for 2 hours, and then chilled in a desiccator. Once cool, weigh it using a digital scale. The final weight minus the weight of the empty petri dishes is the sample weight of 0.0005 mm (clay)[9]. Furthermore, the sample in the petri dish was dried in an oven for 2 hours, then chilled in a desiccator. Once cool, weigh it using a digital scale. The final weight minus the weight of the empty petri dishes is the sample weight of 0.0005 mm (clay)[9]. Then the sample in the petri dish was dried in an oven for 2 hours, then chilled in a desiccator. Once cool, weigh it using a digital scale. The final weight minus the weight of the empty petri dishes is the sample weight of 0.0005 mm (clay)[9].

Data analysis

Determination of community structure for mangrove vegetation is done by quantifying the importance value index, distribution of Chao Diversity Estimates, Simpson Dominance Index used in this study. After that, a multivariate analysis was carried out between the physical and biological factors of the mangrove ecosystem and the gastropod community using the Canonical Correspondence Analysis (CCA) method.

Figure 1. Location of study, Muara Gembong, Bekasi, West Java

Results

The results of observations in the field there are 4 species of mangrove vegetation in the shoreline area that is resistant to sea wave abrasion at Pantai Bahagia Vilage. The vegetation includes *Avicennia officinalis*, *Avicennia marina*, *Rhizopora apiculate*, and *Rhizopora mucronata*. *Avicennia* and *Rhizopora* are known as true mangrove vegetation. These two species are species that tend to be in the front zoning and function as abrasion resistors from high waves[10–12]. Both genera are suitable vegetation to be on the coastline as vegetation to resist sea wave abrasion.

Table 1. Importance value index of mangrove vegetation

Station	Tree	Puppies	Seedling
	INP	**INP**	**INP**
A1 Station			
AO	**300**	**300**	**200**
Station A2			
AO	**300**	**300**	**200**
Station B1			
AM	**198.8**	**300**	**75**
Station B1			
RA	**101.2**	**0**	**125**
Station B2			
AO	**46.6**	**0**	**0**
RM	**253.4**	**300**	**0**
Station C1			
AO	**194.4**	**243**	**43.3**
RM	**105.6**	**56.9**	**156.6**
Station C2			
AO	**75.9**	**60.8**	**45.8**
RM	**224**	**239.2**	**154.2**

Note: (AO, *Avicennia officinalis*; AM, *Avicennia marina*; RM, *Rhizopora mucronata*; RA, *Rhizopora apiculata*)

The research location is a location that is known to have a high enough abrasion effect, according to Putra et al.[13] the abrasion process occurred continuously from year to year after the establishment of the estuary as permanent production forest in 2005 and after that there was massive land clearing by the surrounding community. In recent years, the community has begun to experience the impact of changes such as land subsidence; many houses have been submerged by tides and the advancement of the coastline to the mainland. This causes the community to become more aware of the importance of the mangrove ecosystem at this time. Some of the research areas are areas resulting from reforestation several years ago.

Table 2. Mangrove gastropod importance index

	INP		INP		INP
A1 Station		**B1 Stasion**		**C1 Station**	
Cassidula aurisfelis	29.4	*Cassidula nucleus*	12.7	*Pirenella cingulata**	111.4
Cerithidea alata	25.9	*Cassidula aurisfelis**	46.6	*Cerithidea alata*	88.6
Pupina sp.*	144.7	*Cassidula vespertilionis*	8.7	**C2 Station**	
A2 Station		*Pythia plicata*	4.5	*Pirenella cingulata**	95.4
Pupina sp *	200	*Laemodonta punctigera*	12.0	*Cerithidea alata*	59.5
		Pirenella cingulata	21.7	*Pupina* sp.	45.1
		Cerithidea quoyii	10.6		
		Cerithidea alata	15.8		
		Littoraria scabra	7.6		
		Littoraria melanostoma	4.5		
		Littoraria carinifera	8.0		
		Littoraria articulata	8,4		
		Neripteron violaceum	3.8		
		*Pupina*sp.	34.9		
		B2 Stasion			
		*Pirenella cingulata**	113.1		
		Cerithidea alata	48.4		
		Pupina sp.	38.4		

The research station is separated into stations A, B and C. Station A is the westernmost area of Pantai Bahagia Village with the influence of fresh water originating from the Sampang River, this location is the location of the results of reforestation. Station B is the middle area of Pantai Bahagia with the influence of fresh water originating from the Beting River, substation B1 is a type of mangrove forest that grows naturally and is naturally old, but substation B2 is an ecotourism location on the Pantai Bahagia Vilage. Station C is the easternmost Pantai Bahagia area from Pantai Bahagia Village with the influence of fresh water from the Jeruju Tributary, whose river has been inactive (loss of water flow) since 2008, so that currently there is no effect of fresh water at the station.

Station A, both at substations A1 and A2, only found *Avicennia officinalis* species. This area is a reforestation area where *A. officinalis* acts as a pioneer in artificial primary succession. Station B, there are 4 species of mangrove vegetation that have been found. Substation B1 consists of *Avicennia marina* and *Rhizopora apiculata*, where the tree structure and saplings of *A. Marina* are more dominant and in the seedling structure *R. apiculata* is more dominant. Substation B2 consists of *A. officinalis* and *Rhizopora mucronata*. The tree structure and tillers were dominated by *R. mucronata*, no individual was found in the structure of the seedlings. Station C there was 2 species that were found, both C1 and C2 substations were found *A. officinalis* and *R. mucronata*. The tree and sapling structure at substation C1 is dominated by *A. Officinalis* and the structure of the seedlings were dominated by *R. mucronata*. The structure of trees, saplings and seedlings at substation C2 was dominated by *R. mucronata*.

The results of gastropod observations in this study have succeeded in finding 14 species of gastropods (Figure 2) which are included in the Potamididae, Ellobiidae, Neritidae, Littorinidae, and Pupinidae families. Based on the results of the INP formulation of substations A1 and A2, *Pupina* sp. Station A is a mangrove conservation reforestation station, at substations A1 and A2 there is a high dominance of these species which is predicted to occur due to an artificial primary succession process. Substation B1 was dominated by *Cassidula aurisfelis*, followed by *Pupina* sp. and *Pirenella cingulata* (Synonym: *Cerithidea cingulata*). Station B2, C1, and C2 are dominated by *P. cingulata*.

Diversity index analysis can be seen in Figure 3. The highest diversity is at station B1 with a diversity index value of 14, while other stations such as A1, A2, B2, C1 and C2 are classified as low with an index value less than the same as 3.The highest dominance index value available at stations A2 and A1. Station A has a low diversity value because the station is a restoration location (artificial ecosystem) made by local residents in overcoming the rate of abrasion that occurs on Pantai Bahagia Vilage. Station A is a station that is influenced by the mouth of the Sampang River at Pantai Bahagia Vilage. The low value of the diversity index and the high index of dominance explain that this location is still included in the primary succession phase as explained by Ernawati et al.[14], Nuha[15], and Winarno et al.[16]. Station B is a station that is influenced by the estuary of the Beting River. Station B is a natural ecosystem that is currently experiencing a high rate of damage due to abrasion. Station B is separated into substation B1 and substation B2, substation B1 is a natural area that is rarely visited by tourists and substation B2 is a gathering point for tourists on mangrove ecotourism where the origin is a natural mangrove ecosystem on the Pantai Bahagia Beach.

Figure 2. Gastropod shell morphology collection in research samples: 1. *Cerithidea quoyii*; 2. *Pythia plicata*; 3. *Cassidula aurisfelis*; 4. *Neripteron violaceum*; 5. *Littoraria melanostoma*; 6. *Littoraria carinifera*; 7. *Cassidula nucleus* 8. *Pirenella alata*, Synonym: *Cerithidea alata*; 9. *Pirenella cingulata*, Synonym: *Cerithidea cingulata*; 10. *Littoraria scabra*; 11. *Cassidula vespertilionis*; 12 *Laemodonta punctigera*; 13 *Pupina* sp.; 14. *Littoraria articulate*

The results of the diversity index analysis show that substation B1 is very good, while substation B2 is classified as low. The dominance index at substation B1 is very low while substation B2 is quite high. This shows that substation B1 has not experienced a significant stress compared to substation B2.

Substation B2 is under good stress due to possible abrasion and tourist stress effects. Station C is a station that is influenced by the mouth of the Jeruju Tributary, but this tributary has been dead for the last 8 years. The results of the diversity index analysis at station C were classified as low and the dominance was moderate to high, which means that this environmental condition was not good for gastropods. Station C is a transition between natural ecosystems and artificial ecosystems.

The distribution analysis of the gastropod community can be seen in Table 3. The distribution of living things in the study of the biosphere generally often occurs in groups because nutritional factors are distributed with a certain tendency in nature, causing different responses in a habitat. The distribution pattern in groups is also influenced by the behavior of the reproductive strategy, the availability of food and environmental conditions[17], by grouping it will be easy to carry out the mating process. Substations A1 (reforestation area), A2 (reforestation area), B2 (ecotourism area), and C1 (high abrasion area) are distributed in groups because the environment at the station is unstable, while at Station B1 has a distribution value ($S2 / \overline{X}$) close to 1, which means the intermediate value between grouped and evenly distributed. The results of the diversity analysis at station B1 also look very good. From this analysis of diversity and distribution, it is clear that substation B1 is undergoing a slow process of environmental degradation. The even distribution pattern is influenced by competition factors. This competition can take the form of scrambling for food and space to live, thus encouraging an even distribution of space[18].

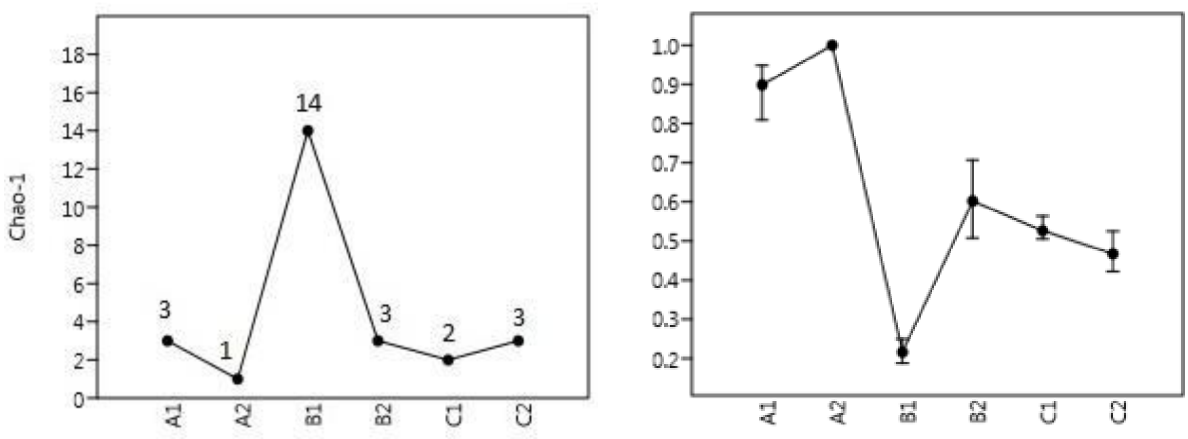

Figure 3. Chao1 diversity index graph and simpson dominance

Substation C2 is evenly distributed (uniformly) predicted due to the minimum input of organic matter from the mainland, with the death of the Jeruju Tributary at this location causing the gastropod community to experience competition because it only gets organic material in situ produced from the mangrove ecosystem. From this analysis of diversity and distribution, it is clear that substation B1 is undergoing a gradual process of environmental degradation. The even distribution pattern is influenced by competition factors. This competition can take the form of scrambling for food and space to live, thus encouraging an even distribution of space[18].

Table 3. Gastropod distribution

Station	A1	A2	B1	B2	C1	C2
Species	**P**	**P**	**CA**	**CC**	**CC**	**CC**
S²	1296.33	867	52	129	1412.33	43
X̄	35.66	17	33	30	48.33	49
S²/X̄	36.34	51	1.5757	4.3	29.22	0.87
Interpretation	K	K	K	K	K	R

Note: Species: P, *Pupina* sp.; CA, *Cassidula aurifelis*; CC, *Cerithidea cingulata*. Interpretation: K, Grouping; R, evenly

Table 4. Gastropod density and mangrove basal areas

	A1	A2	B1	B2	C1	C2
Gastropod Dominance	0.89	1.00	0.21	0.60	0.52	0.46
Gastropod Diversity	3.00	1.00	14.00	3.00	2.00	3.00
Gastropod Density (ind / m²)	38.00	17.00	91.00	40.00	79.00	79.00
Mangrove Basal Area (m / 100 m²)	25.61	48.78	10.52	6.53	16.54	25.44

The results of field measurements of gastropod density (Table 4) show that substation B1 has the highest and lowest density at substation A2. Measurement of basal area in mangrove vegetation communities, both trees and saplings, shows that substation A2 is the highest station and substation B2 is the lowest station. Substation A2 has a high basalt area because the station is the result of forest reforestation.

Table 5. Mangrove ecosystem environmental factors

	A1	A2	B1	B2	C1	C2
pH	6.4	7,2	6.4	6.2	5.3	6.1
Temperature	27.5	28.9	27.2	28.2	27.9	28.1
Canopy Cover (%)	53.25	55.46	56.47	56.35	53.75	55.69
Type of Sediment	LLB	L	LB	L	LB	LB
TDS (ppm)	47	47	74	165	143	53
Salinity (ppt)	45	40	40	40	40	40

Note: Sediment Type: LLB, Sandy Clay Clay; L, Clay; LB, Sandy Clay.

Measurements of environmental factors observed in this study were pH, temperature, canopy cover, sediment type, TDS, and salinity (Table 5). The lowest pH is at substation C1 and the highest is at substation A2. The lowest temperature is at substation B1 and the highest is at substation A2. The highest canopy cover is at substation B1 and the lowest is at substation A1. The type of sediment in the research location is a mixture of sediment from land water flows with sand carried by sea waves, there are 3 types of sediment obtained in the results of this study, namely loam, sandy loam and sandy loam. TDS (Total Disolve Solid) is a solute which is generally a mineral in a solution contained in water[19]. The lowest TDS is at station A while the first and second highest TDS are at substations B2 and C1, this shows that substation C1 may potentially be affected by the flow of the Beting River which is close to substation B2, substation C1 is not affected by the Jeruju River which is closer. The salinity of the entire station is in the sea salinity range, because the research location is carried out on the shoreline.

Discussion

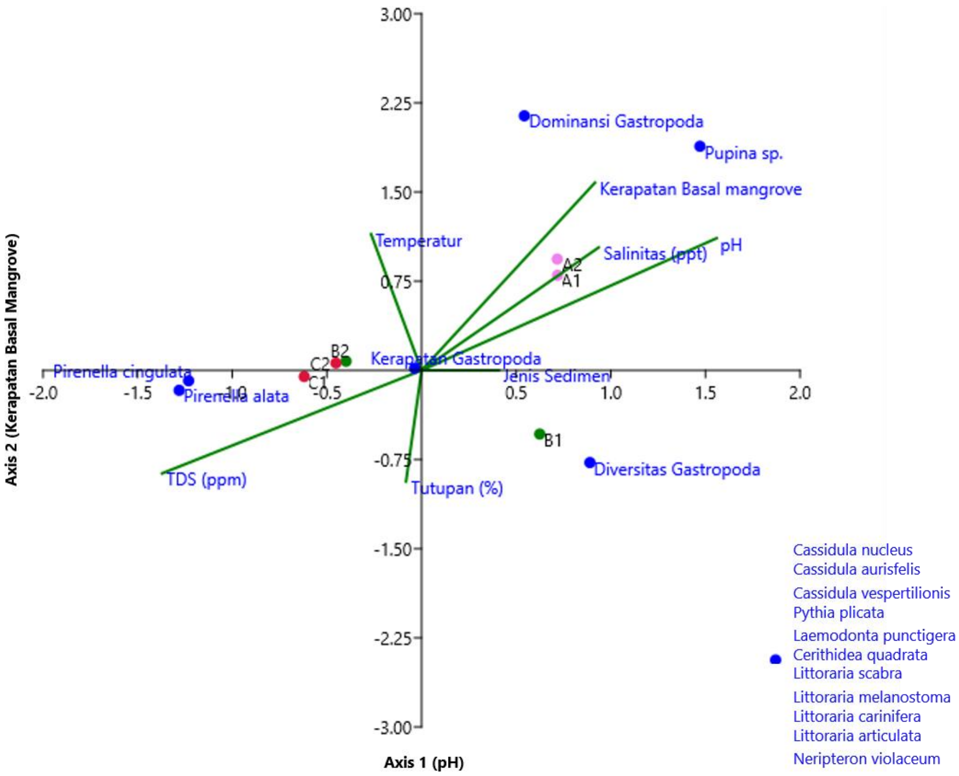

Figure 4. *Scatter* CCA plots between environmental variables and mangrove basal density and gastropod communities

The results of the analysis based on diversity and dominance indices, measurement values for gastropod density, basal vegetation density, gastropod community structure and composition values, and environmental parameters were further analyzed using multivariate CCA (Canonical Correspondence Analysis) analysis (Figure 4). The eigenvalues and correlations of CCA ordination indicate that pH, mangrove basal density, canopy cover, sediment type, and TDS are variables that holistically contribute to gastropod communities, respectively. This is confirmed by the CCA scatter plot which shows that the majority of gastropod taxon are grouped on the same side with pH as the variable with the largest linear correlation value, namely 62.14%. The pH value is an important indicator in water, including the mangrove ecosystem. The pH value is an indicator of the productivity of the mangrove ecosystem[20–22]. Based on the research of Odum[23,24] and Usman[25], pH <6.5 or> 8.5 is an indicator that the waters are unproductive, while the pH range of 6.5-8 is productive waters. Based on the existing standards, it can be concluded that the Pantai Bahagia Mangrove Ecosystem is categorized as unproductive. This can also be seen from the low diversity of vegetation and gastropods at the study site. In addition, when compared with vegetation density in the study of Marsudi et al.[26], it can be seen that for 2 years, there was no significant addition, even though it tended to decrease due to the utilization process mangroves or reforestation process that are not well evaluated[21,22].

Furthermore, the basal density of mangroves contributed positively by 34.29% to the gastropod community. Mangrove vegetation density can be an indicator of substrate type and nutrient control in a location. The higher the density, the higher the control of nutrients and has good freshwater circulation, so that it can have an impact on the biota of mangrove associations, including gastropods[27,28]. The same thing was also obtained from the research results of Ernanto et al.[29] showed a linear correlation of 84.2%

between mangrove density and gastropod communities. This can be an indication that the gastropod community depends on organic compounds provided by mangroves in that location.

Conclusions

There are 4 species of mangrove vegetation in the shoreline area to resist sea wave abrasion at Pantai Bahagia Village. The vegetation includes *Avicennia officinalis*, *Avicennia marina*, *Rhizopora apiculata*, and *Rhizopora mucronata*. Gastropod observations have found 14 species of gastropods belonging to the Potamididae, Ellobiidae, Neritidae, Littorinidae, and Pupinidae families. The location of this study shows that the environment is experiencing environmental degradation based on the diversity index, dominance index, and gastropod distribution. The CCA ordination indicated that pH, mangrove basal density, canopy cover, sediment type, and TDS were the variables that holistically contributed to the gastropod community, respectively. The majority of gastropod taxons were clustered on the same side with pH as the variable with the largest linear correlation value, namely 62.14%. Furthermore, the basal density of mangroves contributed positively by 34.29% to the gastropod community.

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Conflicts of Interest

There are not potential conflicts of interest.

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