



The Influence of Environmental Factors on the Diversity of Gastropods in Marsegu Island, Maluku

Wiwien Bula¹, Fredy Leiwakabessy², ✉ Dominggus Rumahlatu²

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¹Postgraduate Biology Education Study Program, Universitas Pattimura, Indonesia

²Biology Education Study Program, Faculty of Teacher Training and Education Science, Universitas Pattimura, Indonesia

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Abstract

Gastropods are known to have a wide distribution. They can live in a variety of habitats and influenced by various environmental factors. The aim of this study was to investigate the diversity of gastropods and its relationship with the physical and chemical environment of a water. This research was an ecological research with correlational descriptive type. The selection of Marsegu Island was based on the fact that the area is a conservation area, both the forest and sea are frequently visited by tourists. The results of this research showed that there were 22 species of gastropod found in the water of Marsegu Island. The most commonly found was from the genus of *Cypraea* (5 species). Gastropods found mostly from the family of Strombidae which consisted of 4 genera i.e. Lambis, *Canarium*, *Strombus* and *Lentigo*. The value of gastropod diversity in the three research stations was moderate, 2.93, 2.91 and 2.95 respectively. In addition, there is a correlation between environmental factors and the diversity of gastropods. The simultaneous effect of the independent variables toward the dependent variables can be explained by the magnitude of the determination coefficient (*R Square*) which was 0.528 or 52.8%. Result of this study confirms that the environmental factors greatly affects the diversity of Gastropod in the coastal waters of Marsegu island. The results can provide benefits as control over fishing and coastal pollution due to human activities.

How to Cite

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✉ Correspondence Author:

Jl. Ir. M. Putuhena, 97233 Ambon

E-mail: dominggus_amq@yahoo.co.id

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INTRODUCTION

Mollusks are the second most species rich invertebrate after the insects, in which the number of the species reaches 80.000 to 135.000 and among these, the most common species are found in the marine environment (Sakthivel & Fernando, 2014; Ahmadreza *et al.*, 2012). Mollusk phylum consists of two classes i.e. gastropods and bivalves (Bouchet *et al.*, 2005). Gastropods are known to live in a high diversification of habitats ranging from seas, swamps, rivers, lakes, and forests (Beck, 1998). Gastropods generally have a single shell which is twisted into spirals. Some types of gastropods have quite different features, such as not having a shell, generally with two pairs of broad and flat leg tentacles, having a mantle cavity and internal organs, shelled, head, and legs are cut off, approximately have one or two gills, breathing with the lungs, approximately have one or two reproductive organs, fertilization occurs internal and external (Galan *et al.*, 2015; David, 2013).

In the aquatic environment, some species of gastropods are detritus feeder. They eat leaf litter or the other circulating substances that are suspended in water in order to get food. In sea water, gastropods are more widespread in the littoral region. They are found in a variety of habitats such as mangrove forests, coral reefs, rocky beaches, sandy beaches, seagrass and deep sea (Khade & Khade, 2016). Factors that affect the diversity of gastropods, including (1) the presence of pollutants (Suratissa & Rathnayake, 2017), (2) environmental physicochemical factors (Udayantha & Munasinghe, 2009), and (3) the substrate (Dmitrović *et al.*, 2016).

Some research results found that a high CO₂ in the atmosphere can be absorbed by the sea water to lower the pH and to increase the water temperature. Globally, the sea surface temperature increases 0.76°C and global pH decreases by 0.1 units due to an increase in CO₂ emissions originating from various types of industries (Caldeira & Wickett, 2005). The increase of CO₂ absorption by ocean water will trigger a change in the chemical composition of carbonate followed by the decrease of calcite, aragonite saturation and ion carbonate of sea water. This change is a serious threat to marine organisms, especially those requiring calcium (Liu *et al.*, 2012).

Based on the results of those researches, it is important to conduct a research to ensure the sensitivity of gastropods toward the environmental factors. One of the coastal areas that have the potential of gastropod is Marsegu Island in Ma-

luku Province, Indonesia. The territorial sea of Marsegu Island has an area of 10,000 Ha, and it is also designated as a Nature Park through the decision letter of the Minister of Forestry and Plantation No. 114/Kpts-II/1999. There has not been any research related to gastropods content in the coastal areas of Marsegu Island that has been conducted. Therefore, this research is very important to determine the ecological status of gastropods and environmental factors that affect the diversity of gastropods. Thus, this research aims to examine the biodiversity of gastropods and physical-chemical factors of environment that affect the diversity of gastropods in the water of Marsegu Island.

Given the abilities of Gastropods to adapt and live in diverse aquatic environments, this study is important to assess and the results can provide benefits as control over fishing and coastal pollution due to human activities.

METHODS

This research was conducted in July 2016 at the three stations in the coastal water of Marsegu island, with the coordinates of 3°42' - 3°54' LS and 129°50' - 129°62' BT (Figure 1). The data collection was done by using sampling technique to measure the environmental factors (temperature, salinity, pH and dissolved oxygen of seawater) and the enumeration of the types of gastropods with an in-situ technique.

The data were collected at the lowest tide, starting with determining the sampling area and then making a vertical transect line from the highest tide limit as many as 10 transect lines (toward the sea) with the distance between the transect lines is 50 m. In each transect, 10 plots of 1 × 1 m were created with the distance between the plots is 10 m to obtain 100 plots for each data collection station.

The measurements of environmental factors (temperature, salinity, pH, and DO) were carried out on each plot for 10 transect lines in the morning, at noon and in the afternoon. The equipments for measuring the temperature, salinity, pH, and oxygen content of seawater were thermometer, refractometer, pH meter, and DO meter respectively. The data collection of the types of gastropods was carried out with enumeration and each type of gastropod was photographed in the research location. After that, each type of gastropod was identified using the identification book by Sabelli (1979).

The diversity of gastropods was analyzed descriptively using the Shannon-Wiener diversity

index, as follows.

$$H' = - \sum P_i \ln P_i \text{ (Brower } et al., 1990)$$

where: $P_i = n_i / N$

H' = Shannon–Wiener diversity

n_i = total individual species- i

N = total number of individuals of all species.

There are criteria of diversity used in this study i.e. low ($H < 2$), moderate ($2 < H < 4$), and high ($H > 4$). To examine the correlation between the environmental factors and the diversity of gastropods, the available data were analyzed using multiple linear regression analysis technique.

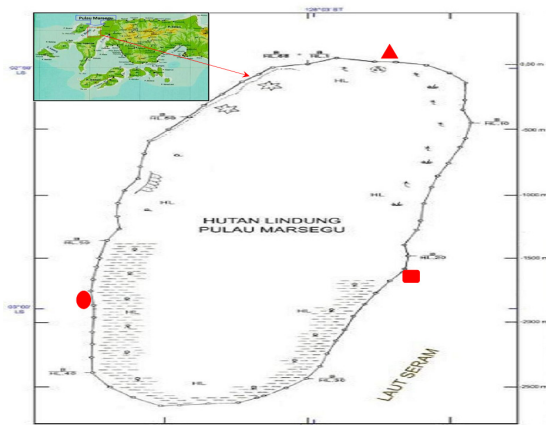


Figure 1. Map of research location (note: ● station 1; ▲ station 2; ■ station 3)

RESULTS AND DISCUSSION

Physical-Chemical Factors of Environment

The results of the measurement of envi-

ronmental physical-chemical factors (Table 1) show that there are fluctuations of environmental physical-chemical factors in the water of Marsegu island, which were measured in the morning, afternoon and evening.

Fly *et al.* (2012) explained that the intertidal zone is an area that has extreme temperature fluctuations which is influenced by solar radiation and the CO₂ content in the water. Szathmary *et al.* (2009) also explained that the changes in environment temperature will affect the body temperature of organisms.

The salinity tended to be more stable in the three research sites, both in the morning, afternoon and in the evening. The average salinity in the three research sites was 51 ‰ (Table 1). The difference was only at station 3 where the salinity was 52 ‰ in the evening. Javanshir (2013) explained that salinity is one of the important environmental factors and affects the vitality of various aquatic organisms. Montory *et al.* (2014) added that organisms living in the intertidal zone are often confronted with fluctuations in sea salinity resulted in stress on their physiological conditions. However, the results of this research found that the salinity of water in the intertidal zone in the water of Marsegu island is more stable and support the distribution of organisms.

The results of pH measurement showed that there was not any fluctuation in the pH of sea water in the three research sites in the morning, afternoon, and evening with the average pH of 7. Moulin *et al.* (2011) explained that the increase in the CO₂ concentration in the atmosphere as a result of human activity will lower the pH

Table 1. Results of the measurement of environmental physical chemical factors in coastal water of Marsegu Island

Parameter	Observation Station	Time		
		Morning	Noon	Afternoon
Temperature (°C)	St. 1	27.8	29.9	26
	St. 2	28	30.16	26
	St. 3	27.9	30.14	25.9
Salinity (‰)	St. 1	51	51	51
	St. 2	51	51	51
	St. 3	51	51	52
pH	St. 1	7	7	7
	St. 2	7	7	7
	St. 3	7	7	7
DO (mg/L)	St. 1	4.16	3.02	2.38
	St. 2	4.06	3.19	2.07
	St. 3	3.79	3.06	2.67

(Note: St = Station)

Table 2. The composition of the taxa of Gastropods obtained in the Coastal Water on Marsegu Island

Family	Genus	Species
Strombidae	Lambis	<i>Lambis lambis</i>
	Canarium	<i>Canarium urceus</i>
	Strombus	<i>Strombus mutabilis</i>
		<i>Strombus gibberulus</i>
	Lentigo	<i>Lentigo lentiginosus</i>
Cypraeidae	Cypraea	<i>Cypraea vitellus</i> (Linne, 1758)
		<i>Cypraea errones</i> (Linne, 1758)
		<i>Cypraea ovum</i> (Linne, 1758)
		<i>Cypraea annulus</i> (Linne, 1758)
		<i>Cypraea tigris</i>
Trochidae	Trochus	<i>Trochus niloticus</i>
Conidae	Conus	<i>Conus eburneus</i>
		<i>Conus muriculatus</i> (Sowerby, 1833)
Costellariidae	Vexillum	<i>Vexillum rugosum</i>
Neritidea	Nerita	<i>Nerita</i> sp
Cerithiidae	Rhinoclavis	<i>Rhinoclavis vertagus</i>
	Clypeomorus	<i>Clypeomorus concisus</i> (H & J, 1854)
Nassariidae	Nassarius	<i>Nassarius albescens</i>
		<i>Nassarius livescens</i>
Volutidae	Cymbiola	<i>Cymbiola vesperilio</i>
Buccinidae	Engina	<i>Engina medicaria</i> (Linne, 1758)
	Cantharus	<i>Cantharus undosus</i> (Linne, 1758)

and saturation of carbonate ions in seawater. The Ocean acidification will reduce the physiological performance of various types of organisms (Paganini *et al.*, 2014)

The results of seawater DO measurements indicated that there was a fluctuation of dissolved oxygen in the morning, afternoon and evening. Jack *et al.* (2009) explains that oxygen is an important factor for respiration of all living organisms.

Gastropod Composition

The results of the enumeration of gastropod species at the three research stations were further identified and classified according to the order of taxon (Table 2). The identification of gastropods showed that there were 22 species of gastropods in the water of Marsegu Island (Figure 2).

The most commonly found Gastropod species are from the genus of *Cypraea* (5 species). Strombidae was the mostly found family which consisted of 4 genera i.e. *Lambis*, *Canarium*, *Strombus* and *Lentigo*. This result is almost similar to the research's results by David (2013)

that found 86 species, 51 genera and 24 families at 16 intertidal zone research stations in Goa, India. Rumahlatu & Leiwakabessy (2017) found as many as 65 species, 48 genera, 19 and 7 orders in the intertidal zone of Ambon Island water. Rahmasari *et al.* (2015) found 29 species, 14 families in three research stations on the southern coastal of Pamekasan Madura.

Gastropoda Diversity

Data of the number and types of individuals were then analyzed to determine the index of diversity, evenness and gastropod richness in the water of Marsegu Island (Table 3).

The index analysis of diversity, evenness, and the richness of types of Gastropod in the three research stations (Table 3) showed a difference result. Based on the results of the data analysis (Table 3), it can be concluded that the diversity of gastropods in the three research stations is in moderate category. Morris *et al.* (2014) explain that biodiversity reflects the variation and heterogeneity of features at all hierarchical levels of the biological system, from molecules to ecosys-

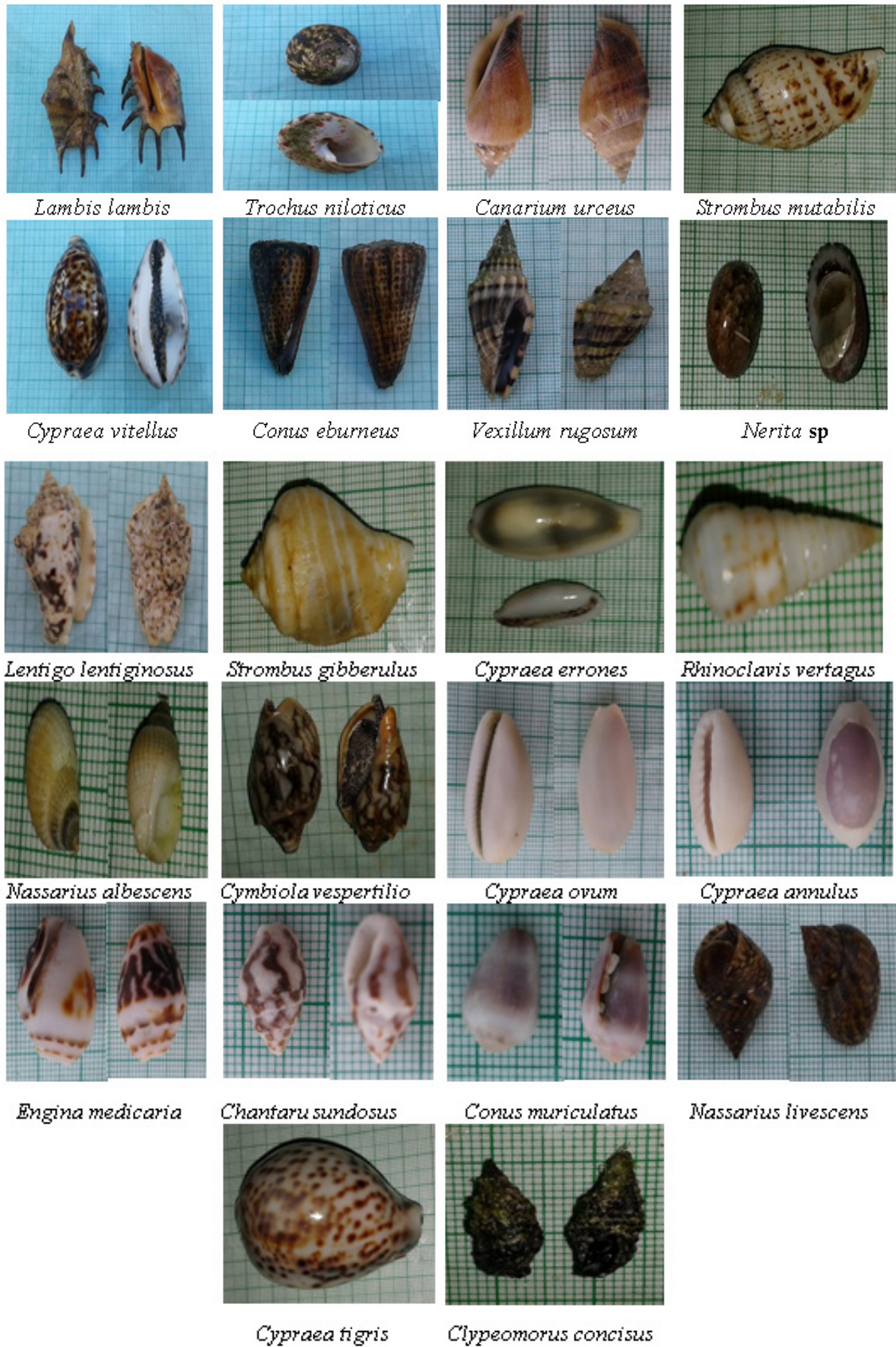


Figure 2. Gastropods found in the Coastal Water of Marsegu Island

Table 3. Index of Diversity, Evenness and Richness of Gastropod's Types

Station	Diversity Index	Evenness Index	Richness Index
Station 1	2.93	0.96	0.33
Station 2	2.91	0.94	0.36
Station 3	2.95	0.95	0.34

Table 4. Results of Multiple Linear Regression Analysis

Model	R	R Square	Adjusted R Square	R Square Change	F Change	Sig. F Change
1	.766(a)	.587	.570	.587	33,742	.000

a Predictors: (Constant), Temperature, Salinity, pH, DO

Table 5. Summary of the Regression Coefficients of each Independent Variable

Model		Unstandardized Coefficients	Standardized Coefficients	t	Sig.
		B	Beta		
1	(Constant)	-8.126		-3.310	.000
	Temperature	.155	.344	2.514	.014
	Salinity	-.212	-.742	-2.872	.000
	pH	1.601	1.535	5.841	.000
	DO	1.203	1.063	5.568	.000

tems. Biodiversity is generally calculated through an index based on species richness and density (Schleuter *et al.*, 2010). This means that diverse communities within an ecosystem will increase the stability, productivity and resistance to invasions and other disturbances.

The Correlation between Environmental Factor and Diversity of Gastropods

The results of multiple linear regression analysis (Table 4) shows that the correlation coefficient of variable temperature, salinity, pH and dissolved oxygen (DO) simultaneously is R= 0.766 with significance level of regression coefficient 0.00. This reveals that there is a significant simultaneous correlation between the physical-chemical factors of environment and the diversity of gastropods. The magnitude of the effect of the independent variables simultaneously on the dependent variable can be explained by the magnitude of the determination coefficient (R Square) (Table 4) that is equal to 0.528 or 52.8%.

Based on the result of regression analysis (Table 4), it can be explained that variation of 58.7% gastropod diversity can be explained by regression model, while the rest 41.3% is the influence of other factors which can not be explained by regression model. The results of the multiple regression test indicate that there is a significant correlation between independent variab-

les and dependent variable simultaneously. Thus, the analysis was continued to know the level of significance of the regression coefficient of each independent variable by using the T test (Table 5).

The environmental factor that greatly affects the diversity of gastropods is water temperatures. The results of statistical analysis show that there is a significant positive correlation between water temperature and gastropod diversity. This means that gastropods like the aquatic environment with relatively high temperatures. The average temperature in the coastal water of Marsegu Island is 26-29°C. This temperature range is highly favored by tropical gastropod. Temperature affects the rate of biochemical, physiological processes and the stability of biomolecules (Hofmann & Somero, 1995; Sanford, 2002). High temperatures can also influence the rate of digestion, respiration, metabolic activity, growth, reproduction and gametogenesis in poikilothermic organisms (Navarro *et al.*, 2000; Christophersen & Strand, 2003).

An extreme temperature increase will also affect the stability of biomolecules. Hawkins (1995) explains that the molluscs are very sensitive to high temperatures beyond the tolerance limit. This is associated with longer metabolism and high resources for survival. Sokolova & Portner (2003) explained that the metabolism of

tropical gastropods can take place at a temperature of 25-40°C. According to Garg *et al.* (2009), the number of decomposers at high water temperatures get bigger as well the increase in water temperature that will activate the decomposition process of organic matter in the sediment.

The salinity is also known to be a limiting factor for food distribution of aquatic organisms. Therefore, it affects the physiological processes, such as hemolymph osmolarity, the water content in the tissue as well as some sub lethal effects (Matsuda *et al.*, 2008; Taware *et al.*, 2012; McFarland *et al.*, 2013). The results of this research also found that there is a significant correlation between salinity factor and the diversity. This means that salinity is one of the environmental factors affecting the distribution and diversity of gastropods in the intertidal zone. Koprivnikar & Poulin (2009) explain that the higher the salinity, the smaller the diversity rate of gastropods. The results show that salinity in the waters of Marsegu Island is relatively stable or does not show any fluctuation, i.e. 51 ‰. According to Portner (2010), high water temperatures will have an impact on the individual's ability to survive. Xiao *et al.* (2014) explained that salinity is a limiting factor in the distribution of aquatic organisms and they have an effect on the physiological processes, such as hemolymphs osmolarity and water content in tissues that can lead to the death of the organism.

The pH is also known to have an effect on the distribution of gastropods, and correlates with the diversity of gastropods. The average pH at all three stations was 7.3 and showed a significant effect on the diversity of gastropods. The positive correlation means that the higher the pH, the higher the gastropod diversity will be. Some other researchs found that acid water will reduce shell thickness and increase the metabolism (hypermetabolism) (Bibby *et al.*, 2007), disturbance in regulating the the hemolymph osmolarity, and ion concentration (Ewald *et al.*, 2009) increases the energy needs so that the cell size decreases, but the body mass increases (Harvey *et al.*, 2016).

The results of this research indicate that there is a significant correlation between DO with the diversity of gastropods. The results of the analysis show a positive correlation, which means that the higher the dissolved oxygen, the higher the gastropod diversity. If the oxygen concentration in the water is too low, it can cause hypoxia and disrupt the ability of individuals to survive (Ekau *et al.*, 2010). At the community level, hypoxia can cause changes in the density and distribution. It will damage the community com-

position by eliminating sensitive species as well as providing opportunities for the more tolerant species to develop more. It also affects the body size of gastropod that lives in the deep ocean (Weisberg *et al.*, 2008; McClain & Rex, 2001). The results of this study have provided information that water physical-chemical factor is very influential on the diversity of gastropod in the coastal waters of Marsegu Island, and indicate that coastal waters of Marsegu island have not been contaminated by human activities.

The benefit of this study is to give information on the physical-chemical factors affecting the diversity of gastropods, so that the community is expected to continue to reduce the habit of over fishing and coastal pollution due to human activities so that the waters quality of Marsegu Island is maintained.

CONCLUSION

Based on the results and discussion, it can be concluded that there are some fluctuations of the physical-chemical factors of the environment in the water of Marsegu Island. The fluctuations were revealed at the temperature and dissolved oxygen, while the salinity and pH did not fluctuate. On the other hand, the results of gastropod identification obtained 22 species with the most common species found were from the *Cypraea* genus (5 species). The index value of diversity, evenness, and the richness of gastropod types shows a difference in the three research stations. In addition, the results of multiple linear regression analysis show that there is a significant simultaneous correlation between environmental physical chemical factors and gastropod diversity. Thus, it can be explained that 58.7% of variation in gastropod diversity can be explained by the regression equation model, while the remaining 41.3% is the effect of other factors that cannot be explained by the regression equation model.

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