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Diversity of gastropods as bioindicator of the coastal waters of Inner Ambon Bay

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Abstract. The beach in Inner Ambon Bay is used by coastal communities to carry out various activities including household waste disposal, fishing activities and tourism. These activities cause the entry of waste into water bodies resulting in a decrease of water quality. This will lead to pollution on the coast if left unchecked. One of the resources living on the coast is gastropods which are generally able to describe waters conditions, so their presence can be used as an indicator for determining water quality. This study aims to determine the diversity of gastropods and the conditions of Halong coastal waters. This research was conducted in 2022 on the coast of Halong waters. Gastropods were collected using the belt transect method with distance between transects is 50 m. Gastropods collected were identified morphologically using standard literature book. Analysis was conducted to determine species density and ecological index of gastropods. The condition of the coastal waters of Halong was determined using STORET method and ABC curve method. The results showed that gastropods in the coastal waters of Halong consist of 3 orders, 13 families, 16 genera and 28 species with the highest density belongs to *Cortica herbs*. Diversity and evenness of gastropod in the area can be categorized as moderate with low dominance. Analysis of physical, chemical and biological parameter indicate that coastal waters of Halong was moderately polluted.

1. Introduction

Halong coastal waters is one of the coasts located in Inner Ambon Bay with a high level of activities such as dumping garbage from the land due to rain falling into small rivers, sedimentation, abrasion and being used as a tourist spot. All of these activities lead to the formation of contaminants (waste). Pollutant waste generated from daily human activities has the potential to endanger the life of inland and marine waters and in particular, it can disrupt the development of organisms in these waters. Increasing human activity in various sectors of life has resulted in increasing environmental pressure on waters, so that one day it can exceed the seawater balance resulting in polluted aquatic systems [1].

The amount of contaminants in wastewater will cause a decrease in dissolved oxygen levels in the water. So that it will disrupt the life of biota in water that requires oxygen and reduce their development. In addition, death can also caused by toxic substances which also can damage aquatic plants which are food for aquatic biota [2]. One of the biotas found on the coast of Inner Ambon Bay is derived from the Gastropod class Mollusc phylum which is often consumed as a substitute for fish.

Gastropods come from the Greek (Gaster: stomach, Podos: legs), which are usually known as organism with a head with 2 or 4 tentacles and a hind leg. The Gastropod class is commonly known as the snail [3]. Gastropods are generally able to describe water conditions, so their presence can be used as an indicator for determining water quality. In addition, the level of diversity in organisms in the aquatic environment can be used as an indicator of pollution. [4]. Gastropods (snails) are sensitive to changes that occur in the environment and are included in the group of facultative organisms that can survive a range of environmental changes that are not too wide. Biota that can be used as a biological parameter in determining the condition of waters are macrozoobenthic animals, for example, members of the gastropods [5].



The coast of Halong beach which is located in Inner Ambon Bay is a coastal area whose waters are widely used by the local community for household activities, fishing activities, sea transportation shipping activities and tourism activities. The number of these activities will affect the diversity of gastropods and the quality of the water on the beach. So, it is necessary to conduct research on the diversity of gastropods and the quality of the waters of the coast, so that this research can be used as a recommendation for management of the Halong coast.

2. Materials and Method

2.1. Sampling

The research was conducted in the coastal waters of Halong (Figure 1) in July to August 2022. Sampling of gastropods was done at low tide by using belt transect [6] in which distance between transect is 50m. Gastropods collected at each quadrant were put into plastic sample and then labelled.

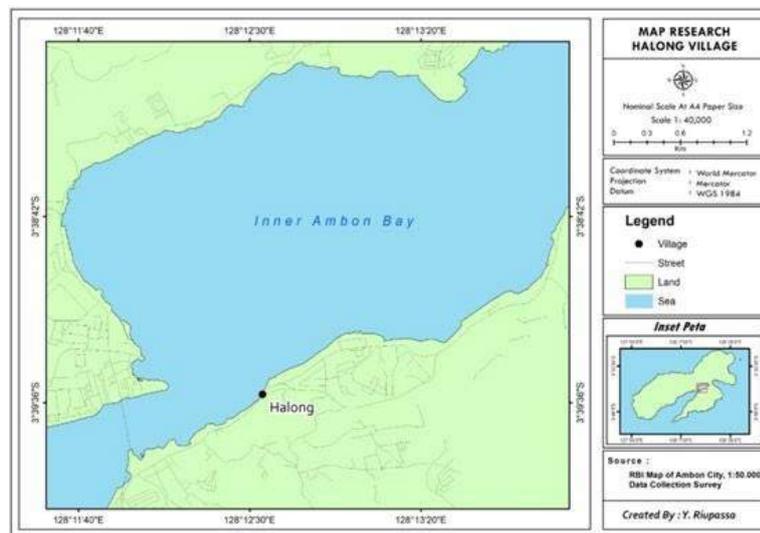


Figure 1. Research location (black circle)

2.2. Sample analysis

In the laboratory, gastropods collected were wash, then put back into labelled plastic which is filled with 70% alcohol. Identification of gastropods was done based on standard identification book [7, 8]. Analysis of nitrate and phosphate was carried out at the Laboratory of the Health Office and Medical Calibration Devices, Maluku Province (KBLK) and the Technical Center for Environmental Health and Disease Control Class II Ambon.

2.3. Data analysis

Data were analyzed using following formulas [9] as follow:

a. Absolut density $D_i \text{ (ind/m}^2\text{)} = n_i / a$

b. Relative density $D_t \text{ (\%)} = D_i / D_t \times 100$

where: D_i = density of i^{th} species

n_i = number of individuals of i^{th} species

a = sampling area

Dt = total density of all species

- c. Shannon-Wiener index (H')

$$H' = -\sum (pi \ln pi)$$

- d. Evenness index (E)

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

- e. Simpson Dominance index (D)

$$D = \sum (pi)^2$$

where: $P_i = n_i/N$

n_i = number of individuals of i^{th} species

N = total number of individuals

$H' maks = \ln S$

\ln = natural logarithm

S = total number of species

- f. Determination of Water Quality Status with the STORET (Storage and Retrieval) Method

The STORET method is a method for determining the status of water quality. By using the STORET method, it is possible to find out the parameters that have met the quality standards or which have exceeded the quality standards. The principle of the STORET method is to compare the water quality standards that have been determined according to their designation with the quality of water from a water source to determine the status of water quality [10].

The way to determine the scoring system with the STORET method was to collect data using the time series and find the minimum, maximum and average data values. The values was then compared with the applicable quality standard. If the parameter value is in accordance with the quality standard, then it is given a score of 0, however if the parameter value does not match the quality standard, then it is given a score according to the US-EPA (United States - Environmental Protection Agency) water quality status classification table (Table 1). In the end, calculate the total negative number of all parameters. Waters quality was then classified into four classes based on US EPA (Table 2)

Table 1. Determination of water quality status based on US-EPA [11]

Number of sample	Score	Physical parameter	Chemical parameter	Biological parameter
< 10	Max	-1	-2	-3
	Min	-1	-2	-3
	Average	-3	-6	-9
>10	Max	-2	-4	-6
	Min	-2	-4	-6
	Average	-6	-12	-18

Table 2. Classification of waters quality based on US-EPA 2004 [11]

No.	Class	Value	Score	Explanation
1	A	Excellent	0	Fulfill standard
2	B	Good	-1 - -10	Low polluted
3	C	Moderate	-11 - -30	Moderate polluted
4	D	Bad	> -31	Heavy polluted

g. ABC Curve Analysis (Abundance Biomass Comparison)

This method is used to determine environmental conditions by analyzing total number of individuals per unit area and total biomass (dry weight) per unit area [12] in [13]. The steps for creating the ABC Curve are as follows:

1. List the relative percentages of the total number of individuals per unit area and biomass per unit area of each species of gastropod
2. Rank each species based on the relative percentage of the total number of individuals and biomass per unit area and then make the cumulative dominant of relative percentage.
3. Plotting the ranking data of the total number of individuals per unit area and biomass per unit area on the X-axis and plotting the dominant cumulative percentage data from number of individuals per unit area and weight per unit area on the Y axis.

3. Result and Discussion

3.1. Description of the research location

Halong coastal waters located in Halong village with tourism activities and a place to find clams and snails “bameti”, and close to settlements. The location of Halong village has a river that flows during the rainy season so that there is a change in the subsoil. Abrasion also occurs because local people take sand around the study site (Figure 2).

**Figure 2.** Coastal waters of Halong

3.2. Species composition of gastropods

It was found that gastropods in the coastal waters of Halong consist of 3 orders, 13 families, 16 genera and 28 species as in Table 3.

Table 3. Species composition of Gastropods

Order	Family	Genus	Species
Archegastropoda	Neritidae	<i>Nerita</i>	<i>Nerita balteata</i>

			<i>Nerita signata</i>
			<i>Nerita histrio</i>
			<i>Nerita patula</i>
			<i>Nerita radiate</i>
	Nassariidae	<i>Herba</i>	<i>Herba corticata</i>
	Mitridae	<i>Mitra</i>	<i>Mitra avenacea</i>
			<i>Mitra orbinyana</i>
			<i>Mitra cardinaus</i>
Neogastropoda	Peristerninae	<i>Peristernia</i>	<i>Peristernia nassatula</i>
	Muricidae	<i>Thais</i>	<i>Thais aculata</i>
		<i>Morula</i>	<i>Morula margaticola</i>
			<i>Morula musiva</i>
			<i>Morula biconical</i>
			<i>Morula sp</i>
	Muricidea	<i>Vexilium</i>	<i>Vexilium virgo</i>
	Olividae	<i>Oliva</i>	<i>Oliva olive</i>
	Nassariidae	<i>Nassarius</i>	<i>Nassarius globosus</i>
	Buccinidae	<i>Engina</i>	<i>Engina alevelata</i>
	Conidae	<i>Conus</i>	<i>Conus mutubalis</i>
Mesogastropoda	Cerithidae	<i>Ceritium</i>	<i>Ceritium kobelti</i>
			<i>Ceritium columna</i>
			<i>Ceritium olveolum</i>
		<i>Cerithidae</i>	<i>Clypeomorus moniliferus</i>
			<i>Clypeomerus coralium</i>
		<i>Rhinoclavis</i>	<i>Rhinoclavis sinensis</i>
	Naticidae	<i>Polinices</i>	<i>Polinices tumidus</i>
	Potamididae	<i>Terebralia</i>	<i>Terebralia sulcata</i>

Among those orders, Neogastropoda has more families (7 families) than Archegastroda and Mesogastropoda which have 3 families each. It can be seen in Table 3 that family Cerithidae has 3 genera, followed by family Muricidae with 2 genera, while other families only have 1 genus. Table 3 also shows that genus *Nerita* has the highest species (5 species), followed by genus *Morula* with 4 species then genus *Ceritium* dan genus *Mitra* with 3 species while other genera have 1 or 2 species.

Molluscs including gastropods is sedentary organism which live at the bottom of the waters. Gastropods are affected directly by the changing of environment including the presence of contaminants, thus they can be used as bioindicator of water pollutant [14]. Changing in waters environment can change the species composition of gastropods in the area.

3.3. Density of gastropods

Density of gastropods in the coastal waters of Halong is presented in Figure 3. Species of *Herba cortica* had the highest density (1.68 ind/m²; 59.86%), followed by *Morula margaticola* (0.25 ind/m²; 8.84%), and then *Morula biconica* (0.16 ind/m²; 5.78%). Cumulative relative density for these 3 species is 74.48%, while the rest of 25 species have low density with their cumulative relative density is 25.52%. According to [15], the number presence or absence of gastropods in the study site may be related to the conditions of the substrate or the place where each species lives. The existence of food factors such as detritus and the environment are also very supportive for the life of the species of gastropods found.

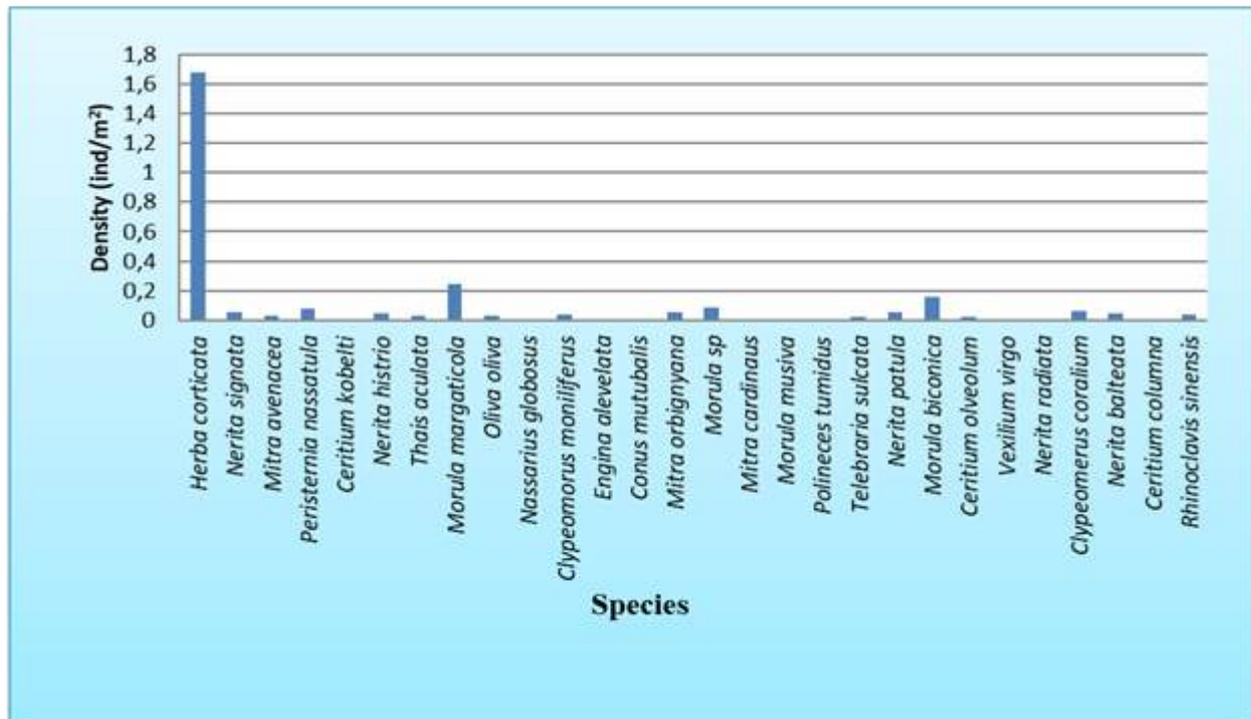


Figure 3. Density of gastropods

3.4. Ecological indexes

Ecological indexes of gastropods in the coastal waters of Halong are represented by Shannon-Wiener diversity index (H'), evenness index (E) and Simpson dominance index (D) and their values are 1.82, 0.53 and 0.34, respectively. Based on those values, gastropods in the area can be categorised as moderate for diversity as well as evenness or uniformity and low dominance.

Moderate diversity of gastropods in the coastal waters of Halong could be due to low number of species and distribution of individuals of the species [16]. Evenness index ranging from 0 – 1, and $E = 1$ means there is equal number of individuals for each species [17, 18]. Dominance index (D) is used to determine if there is any dominance species in a community [19] and its value ranging from 0 – 1 [20]. The value of $D = 0.34$ means that dominance is low in the community of gastropods in the coastal waters of Halong.

3.5. Physical and chemical parameters

Physical and chemical parameters is presented in Table 4. It can be seen in Table 4 that most of physical and chemical parameters fulfil quality standard of the Decree of Minister of Environment No. 115 of 2003 except for phosphate both in the waters and substrate. High concentration of phosphate might be due to fertiliser used by local farmer. This fertiliser is flushed by the rain and flows through the river into the coastal waters of Halong.

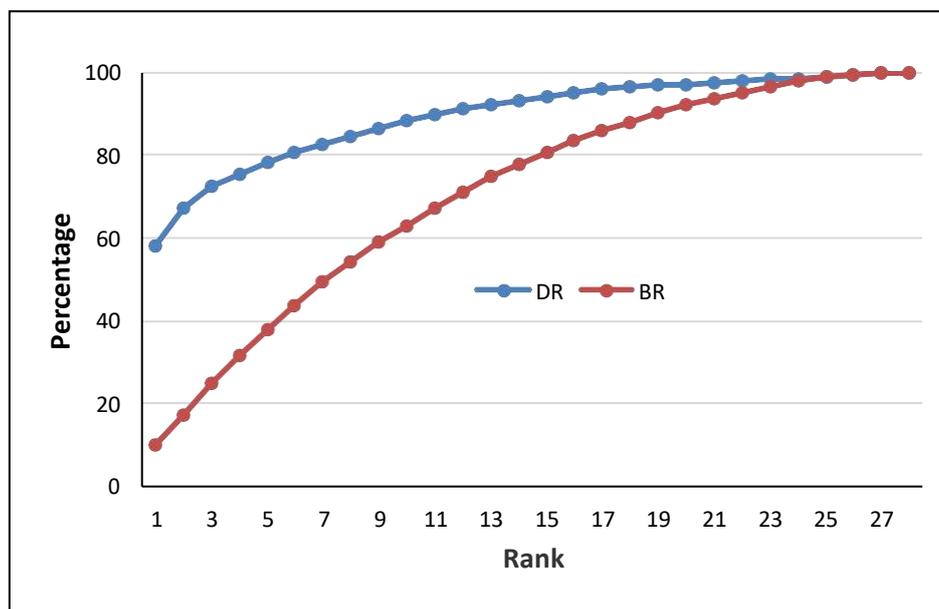
Environmental status can be seen by the storet index which will provide overall information on the status of pollution in the aquatic environment [21, 22]. By using STORET method and the score of US-EPA, the coastal waters of Halong is classified into class C and can be categorised as moderate polluted (see Table 2 and Table 3 for the criteria).

Table 4. Physical and chemical parameters in Halong coastal waters

Parameter	Halong	Quality standard	Score
Temperature (°C)	28.97	28-32	0
pH	7.11	7-8.5	0
pH substrate	6.90	7-8.5	0
DO (mg/l)	6.68	>5	0
Nitrate (mg/l)	0.01	0.008	0
Nitrate substrate (mg/l)	0.02	0.008	0
Phosphate (mg/l)	0.10	0.015	-10
Phosphate substrate (mg/l)	0.56	0.015	-10
Salinity (ppt)	29	≤ 34	0
		Total	-20

3.6. Abundance Biomass Comparison (ABC) curve

ABC curve is used to determine environmental conditions by analyzing total relative density (DR) and relative biomass (BR) of gastropods. There are 28 species of gastropods found during the study in the coastal waters of Halong, and those species are used to form ABC curve (Figure 4). It can be seen in Figure 4 that curve of relative number of individuals per unit area (DR) and the curve of relative dry biomass per unit area (BR) is overlapping. The overlapping between these two curves means that the coastal waters of Halong is moderately polluted [23]. If the curve of biomass per unit area is below the curve of the number of individuals per unit area then this condition occurs due to ecological disturbances and pressures [24].

**Figure 4.** Abundance Biomass Comparison (ABC) curve

4. Conclusion

It can be concluded from this study that gastropods in the coastal waters of Halong consist of 3 orders, 13 families, 16 genera and 28 species with the highest density belongs to *Cortica herbs*. Diversity and evenness of gastropod in the area can be categorised as moderate with low dominance. Analysis of

physical and chemical parameters using STORET and biological parameter using ABC curve indicate that coastal waters of Halong is moderately polluted.

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