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Gastropods as Bioindicators of Water Quality in Telindale Beach, Rote Tengah District, Rote Ndao Regency

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ABSTRACT

Telindale Beach is part of the Central Rote Sub-district in the Rote Ndao Regency. The beach is also a seaside region with many community activities, including tourism, recreation, and sales. These activities have a significant impact on the health of aquatic ecosystems. The presence of pollutants in water might cause a decline in its quality. Gastropods are among the species that are sensitive to changes in water quality. This study sought to provide information on gastropod diversity as a bioindicator of water quality at Telindale Beach. This study was both descriptive and quantitative, with the location determined through purposive sampling. The line-transect approach was applied at three locations, each with a different substrate. The data were evaluated using diversity, uniformity, and dominance index techniques. The research revealed that the gastropods identified at the beach belonged to 13 families, 15 genera, and 19 species, with 112 individuals across all stations. The diversity index ranged from 0.27 to 2.33 (moderately contaminated), the uniformity index was 0.84-0.91 (high), and the dominance index was 0.12-0.31 (moderate). According to the species diversity index data, the waters near Telindale Beach were the most polluted.

Keywords: bioindicator, gastropods, Telindale Beach

INTRODUCTION

Coastal areas are often developed as attractive tourist attractions because they have diverse natural potentials, such as mangroves, beaches, fisheries, and various habitats that live around it. Gastropods are one of the biotas that support aquatic ecosystems. Gastropods are shelled animals that walk on the stomach (gastro: stomach; podos: legs). This animal has a locomotion tool that uses the stomach as its legs; they live in the sea and are very sensitive to changes in the quality of the water where they live. The diversity of gastropods can describe aquatic conditions and is important for maintaining the ecological balance of the coast.

The increase in community activities for utilizing gastropods in coastal waters affects the diversity of gastropod species in the area and results in a decrease in the quality of the aquatic environment (Dahuri *et al*. 2016). Gastropods have important economic value because their shells can be used for various garnishes, and their flesh can be used as a foodstuff. Some species of gastropods have a low tolerance for pollution, so their presence or absence can indicate a level of pollution in water. In aquatic ecosystems, changes in gastropod communities often reflect changes in environmental conditions, such as increased pollutants or changes in substrate quality (Abdillah *et al.* 2019). Studies on gastropod diversity can provide a comprehensive picture of the health of marine ecosystems. For example, a low diversity index can indicate habitat degradation caused by human activities, such as waste disposal or excessive harvesting of marine life (Persulessy and Arini 2018). Thus, the analysis of gastropod diversity not only provides information on the status of water quality but can also be the basis for conservation planning and coastal environmental management.

Telindale Beach is one of the beaches located in the Central Rote District, Rote Ndao Regency, a coastal area with high community activity. There are several hang-out places and places to sell food that result in community activities on the beach. This activity includes tourism, recreation, and other tourism activities. If not managed properly, these activities will have a significant impact on the state of aquatic ecosystems.

The decline in water quality can be caused by the presence of pollutants entering water. Telindale Beach is a beach that has a beautiful panorama and the potential for diversity of marine life such as fish, shellfish, and other marine life, one of which is gastropods. The characteristics of the area, which stretches widely and is generally sandy with little coral, make it a popular tourist destination. Excessive activities such as garbage disposal and the extraction of marine life can cause a decrease in population,

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diversity, and water quality. This study aimed to determine the diversity of gastropods as a bioindicator of water quality in Telindale Beach, Central Rote District, Rote Ndao Regency, using the results of this study as a reference for the types of gastropods found at the beach. This research was also expected to provide information, enrich knowledge, preserve marine life, and maintain the quality of the waters at the beach.

METHODS

Time and Place of Research

The research was conducted at Telindale Beach, Central Rote District, Rote Ndao Regency, from August to October 2023.

Tools and Materials

This study used a digital camera to take pictures of specimens, a notebook as a place to record all the results of the observation process in the field, a gastropod identification book, a roll meter to measure and make a research plot, a pH meter to measure pH, a raffia rope to make a research plot, peg wood to fix the angle of each plot, sample bottles to collect samples, and alcohol to preserve the sample. The research used materials in the form of all gastropod specimens, 70% alcohol to preserve the specimens, and label paper for labeling the found specimens.

Procedures

This study was conducted using the purposive sampling method, based on differences in substrates (Fachrul 2007). Gastropod sampling was carried out using the line transect method, consisted of 3 stations; each station consisted of 3 transects, and each transect consisted of 3 plots with a total of 27 plots. The distance between each transect was 50 m, and the distance between plots was 10 m, with a plot size of 1 × 1 m^2.

The discovered gastropods were then identified, and for those that had not yet been identified, samples of each variety were collected and placed in a sample vial, which was then stored in 70% alcohol for identification in the laboratory. To support the findings of this study, environmental parameters such as temperature, pH, salinity, and substrate were monitored. Environmental parameters were measured and observed along each transect.

Data Analysis

The data were analyzed using quantitative and qualitative descriptive using the diversity index formula of Shannon-Wiener:

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

where
H' = Species diversity index
$P_i = (n_i/N_t)$
P_i = Relative abundance of ith species
n_i = Number of individuals of the ith species
N_t = total individuals of all types recorded

Parameters for the Shannon-Wiener index
H' < 1 = Relatively low diversity
H' 1-3 = Moderate diversity
H' > 3 = High diversity

The determination of water quality was based on the index of gastropod species diversity using the Shanon-Winner criteria (Fachrul 2007):
H' > 1 = Heavy polluted
H' 1,0-2,0 = Moderate polluted
H' 2,1–3,0 = Light polluted
H' 3,1–4,0 = Very light polluted
H' > 4 = Unpolluted.

The uniformity index ranges from 0 to 1 and was calculated using the Krebs formula (2014):

$$e = H'/(\ln S)$$

where
e = Uniformity index
H' = Diversity index
S = Number of species
$e < 0.4$ = Low species uniformity
$0.4 < e < 0.6$ = Moderate species uniformity
$0.6 > e > 1$ = High species uniformity

The Simpson dominance index was calculated using the Krebs formula (2014):

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

where:
D = Simpson dominance index
Pi = Comparison of the number of individuals of the ith species (n_i) to the total number of individuals (N)

The criteria for the dominance index according to Simpson (1949):
0 < D < 0.5 = No type dominates
0,5 < D < 1 = There are dominant types

RESULTS AND DISCUSSION

Gastropod Species Composition

At Telindale Beach, researchers discovered gastropods belonging to 13 families, 14 genera, and 19 species (Table 1). The total number of gastropods was 112 ind/m^2. The most common species were *Monetaria annulus* (12 ind/m^2) and *Conus magus* (12 ind/m^2). The high population of this species is due to the substrate in which it lives and forages in sandy and rocky environments. According to Andriati (2020), the genus

Conus can live and adapt to sandy and rocky habitats because they allow for easier movement and shifting to various locations.

The gastropods found at Station I were higher than those at Stations II and III, possibly due to the difference in substrate, namely, the sandy substrate at Station I with rocky substrates at Station II and rocky sandy substrates at Station III. Gastropods found in sandy substrates are more abundant compared to rocky substrates because in sandy substrates, gastropods can immerse themselves and take shelter from currents. According to Ira *et al.* (2015), a rocky substrate with many holes and cavities will be filled with water at low tide and become a type of small tidal pond, which is an ideal place for gastropods to shelter themselves from drought and low tide.

At Station II, the gastropods found were higher than those at Station III, although they had a rocky substrate and a mixed substrate of rocky sand, so fewer gastropods were found due to the limited substrate to attach to and shelter from the currents. According to Fadli *et al*. (2012), currents are a limiting factor in the spread of gastropods because strong currents can reduce the density of gastropods in an area.

Gastropods as a Bioindicator of Water Quality

The quality of the waters based on the gastropod species diversity index on Telindale Beach, Central Rote, and Rote Ndao Regency followed the Shanon-Winner criteria, showing values ranging from 1.27 to 2.33. This index indicates the criteria for lightly and moderately polluted water (Table 2). Unpolluted waters will show a balanced number of individuals, while polluted waters will show a non-uniform distribution of individuals and tend to have dominant species (Shahra *et al*. 2023).

The highest diversity was observed at Station I and the lowest diversity index was at Stations II and III. The diversity index of each station is in line with the Shannon-Wiener diversity criteria: Station I with a value of 2.33 (lightly polluted), Station II of 1.64 (moderately polluted), and Station III of 1.27 (moderately polluted). Although there were differences in the diversity index at each station, the difference was not significant. Factors that determine high species diversity in a location are influenced by the physical conditions of the environment. The environmental physical conditions and type of substrate at the three stations were relatively the same, so that moderate species diversity in the same category was obtained.

Low gastropod diversity was found at Station II and Station III, at 1.64 and 1.27, respectively. The low diversity at this station is because this beach area is used as a tourist attraction for some people and is also an area to sell snacks, grilled corn, and drinks. The high level of community activity on this beach resulted in an increase in garbage at that location. This condition was observed during the study, and plastic waste was found on the outskirts of Telindale Beach. During the study, no garbage cans were found at any point where sales were conducted. In addition, the small value of diversity in this station is due to the habit of people who consume gastropods to sell or consume as foodstuffs, for example from the genus *Cymbiola,* which is not found at the research site. Based on the type of diversity index indicator at Station I, the water condition is lightly polluted (*H*' = 2.33), while Stations II and III are in a lightly polluted condition with an *H*' ranging from 1.27 to 1.64.

Species diversity is a community-level characteristic based on biological organization. A community is said

Table 1 Types of Gastropods identified on Telindale Beach

Family	Genus	Species	St. I	St. II	St. III	∑ ind/m^2
Cypraeidae	Monetaria	*Monetaria annulus*	6	6	-	12
Pilidae	Cypraea	*Cypraea moneta*	5	3	-	8
Strombidae	Strombus	*Strombus alatus*	2	-	1	3
	Lobatus	*Lobatus raninus*	3	-	1	4
Olividae	Oliva	*Oliva sericea*	3	-	-	3
Conidae	Conus	*Conus ebraeus*	2	-	3	5
	Conus	*Conus magus*	8	-	4	12
	Conus	*Conus coronatus*	4	-	4	8
	Conus	*Conus lividus*	2	-	2	4
	Conus	*Conus spendidulus*	1	-	3	4
Cerithiidae	Cerithium	*Ceritium vulgatum*	2	-	5	7
	Cerithium	*Cerithium muscarum*	6	-	-	6
Costellariida e	Vexillum	*Vexillum virgo*	-	5	-	5
Muricidae	Morula	*Morula margariticola*	2	5	1	8
Cypraeidae	Mauritia	*Mauritia Arabica*	-	7	1	8
Fasciolariida e	Peristernia	*Peristernia chlorostoma*	-	4	-	4
Turbinidae	Turbo	*Turbo chrysostomos*	-	4	-	4
Pisaniidae	Solenosteir a	*Solenosteira cancellaria*	1	2	-	3
Nassariidae	Nassarius	*Nassarius* sp.	2	-	1	3
Total			50	36	26	112

Remarks: St = Station, I = Sandy; II = Rocky, III = Sandy rocky, and – = None.

to have high diversity if it is composed of many types. However, if the community is composed of very few species and only a few dominant species, then the species diversity is clearly low (Fachrul 2007).

Diversity (*H'*), Uniformity (*e*), and Dominance (*C*) of Gastropods

The calculated overall diversity index (*H'*) at Stations I, II, and III ranged from 1.27 to 2.33; these are included in the medium category (1 < *H'*< 3) (Sandewi *et al.* 2019). The Uniformity Index (*e*) shown in the research results is included in the high category (*e* > 0.6) (Krebs 1985). The dominance index (*C*) at the research location was 0.12–1.24, which according to Odum (1993), is in the category of high species dominance (0.5 < C < 1) (Table 3). The gastropod diversity at the study site was moderate. It is suspected that there is an interaction between species that causes competition, sufficient productivity, fairly balanced ecosystem conditions, and moderate ecological pressure (Piranto *et al.* 2019).

The calculated uniformity index (*e*) at Stations I, II, and III shows relatively high indices, meaning that the number of individuals of each species is relatively the same. According to Subianto and Susilo (2023), if many species are found in an area, the uniformity index obtained will be high and *vice versa*. The gastropod uniformity in this study showed a high uniformity of 0.84-0.91. Odum (1993) stated that the value of uniformity in a high category indicates a large similarity between species, meaning that the abundance of each species is low. This shows that at the research site, there is an interaction between biotic and abiotic components that affect each other, one of which is the uniformity index of gastropods.

The dominance score was included in the high category. A high dominance index indicates a high dominant concentration (there is dominance), on the other hand, if the dominance index is low, the dominance concentration is low, hence there is no species dominance (Subianto and Susilo (2023). Odum (1993) stated that the higher the Uniformity Index, the higher the distribution of individuals of each species, indicating that the distribution of individuals is not the same, and there is no tendency to be dominated by certain species.

Environmental Conditions

The environmental parameters were measured such that the physical state of the environment was in harmony with the ideal state. Based on abiotic factors in the waters of Telindale Beach, the water temperature at the three stations ranged from 28°C to 29°C. The high temperatures in the study area were due to low rainfall. The temperature of the coastal waters is still within the normal range for the growth and development of gastropods. This is in accordance with Nento *et al*. (2013), who stated that the ideal temperature for the growth and reproduction of gastropods is generally in the range of 25–32°C.

The salinity obtained from the three stations ranged from 37 to 38 (‰). These levels are within the ideal range for the growth of gastropods. According to Persulessy and Arini (2018), the ideal salinity for gastropod growth is in the range of 24–39 (‰). Therefore, the salinity of the waters in the beach is still in a state of support for the life of gastropods. Some factors that affect seawater salinity are rainfall patterns, evaporation, and water circulation (Mislan 2021).

The degree of acidity of the waters in the study area is the pH within the tolerance limit for gastropods. The pH of water in ranged from 7.5 to 7.8. These conditions are still considered ideal for gastropods to grow and develop. According to Irnawanti (2016), most aquatic biota is sensitive to pH differences; at pH conditions of 7-8.5, gastropods can survive.

Description of Gastropod Species in Telindale Beach

- ***Monetaria annulus*:** small size, has a slippery shell, is slightly dark on the surface, and is circled by a golden color (Figure 1a). This species is found on sandy and rocky substrates. According to Arini (2018), *M. annulus* has a smooth and shiny body that also has a brownish-white color with two curved yellow stripes that have a

Table 2 Diversity Index (*H'*), Criteria, and Bioindicators of Water Quality Based on *H'* at Telindale Beach, Central Rote District

Parameter	Station I	Station II	Station III
H'	2.33	1.64	1.27
Criterion	Light	Moderate	Moderate
Water quality bioindicators	Lightly polluted	Moderately polluted	Moderately polluted

Table 3 Diversity index, uniformity index, and dominance index at Telindale Beach, Central Rote District

Station	Diversity index (*H'*)	Uniformity index (*e*)	Dominance index (*C*)
I	2.33	0.88	0.12
II	1.64	0.84	1.24
III	1.27	0.91	0.31
Remarks	1< *H'*< 3 Moderate diversity	*e* > 0,6 Highly uniform	0,5 < *D* < 1 Highly dominance

golden yellow color in the shape of a ring. This habitat can be found in seagrass meadow areas with sand (muddy) substrates, fissures, coral reefs, or under rocks.

- ***Crypea moneta*:** found in sandy and rocky habitats with a non-uniform body structure, the surface or shell is gray-gray and has a length of 2–2.5 cm (Figure 2b). According to the literature, C*. moneta* has a thin oval shell with a wide shell mouth and a thin outer lip (Arini 2018). Its habitat can be found on rocks.

- ***Strombus alatus*:** has an non-uniform body surface, a shell size of 3–3.5 cm, a brown shell and a tapered shell tip (Figure 2c). *S. alatus* is a type of gastropod found in sandy and rocky sandy substrates. Based on a study by Alita *et al.* (2021), this species has a spiral shell with less prominent substructural spines and can be found in sandy bottoms among seagrasses.

- ***Lobatus raninus*:** has a non-uniform shell and a brownish and white shell (Figure 2d). This species is a gastropod found on sandy and rocky sandy substrates. According to Alita *et al.* (2021), it has a strong shell that is relatively hard and dense, with a distinctive spiral dorsal curve that is brownish with scattered white spots. It can be found in seagrass meadows in shallow waters.

- ***Olive sericeae*:** has a smooth shell surface and a brownish-gray shell color (Figure 2e) and are found on sandy and rocky sandy substrates. It has a shell resembling a beetle, with a brownish-black color, smooth texture, and a batik-like shell pattern (Andriati *et al.* 2020),

- ***Conus ebraeus*:** is a type of gastropod found in sandy and rocky sandy substrates. This species has a white shell surface with a pattern of small dark boxes arranged in parallel. *C. ebraeus* has a white shell with a black square pattern, found near rocky beaches (Andriati *et al.* 2020).

- ***Conus magus*:** is characterized by a white shell surface and brownish shades (Figure 2g) and is found on sandy and rocky sandy substrates. According to Ahmad (2018), it has a shell surrounded by narrow intermittent stripes combined with white, orange, and brownish colors.

- ***Conus coronatus*:** has a purple shell surface and a white border like color barrier (Figure 2h), and is a gastropod found on sandy and rocky sandy substrates; it is 21–24 mm in size with a conical shape, convex in the upper whorl body, and shrinking downwards (Ahmad 2018). The spire is shorter than the body of his whorl; light purple in color with brown stripes from the base to apex. The aperture is long and narrow and has a purple color with a white stripe underneath. This species is found in shallow water.

- ***Conus lividus*:** has conical characteristics, a brown shell, and a circular white line on the shell (Figure 2i), with habitats in sandy and rocky sandy substrates. According to previous studies, this species generally has a thick shell and conical tip (Ahmad 2018).

- ***Conus generalis*:** characterized by a brownish-orange shell and brownish-white color pattern blooming on the shell (Figure 2j). This species is found on both sandy and rocky sandy substrates. According to Ahmad (2018), it has a brownish orange to brown shell color, with white stripes without rhythm on the shoulders, middle, and base.

- ***Ceritium vulgatum*:** has a cone-like shape, the shell is rough and non-uniform, the shell part is predominantly black and slightly white (Figure 2k), and it is found on sandy and rocky sandy substrates. According to Bhuja *et al.* (2020), this species has a

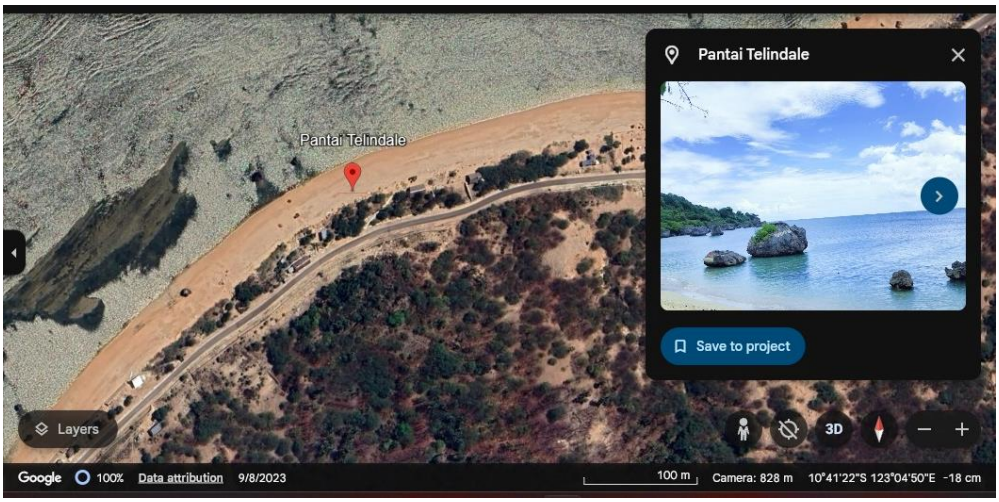

Figure 1 Research location.

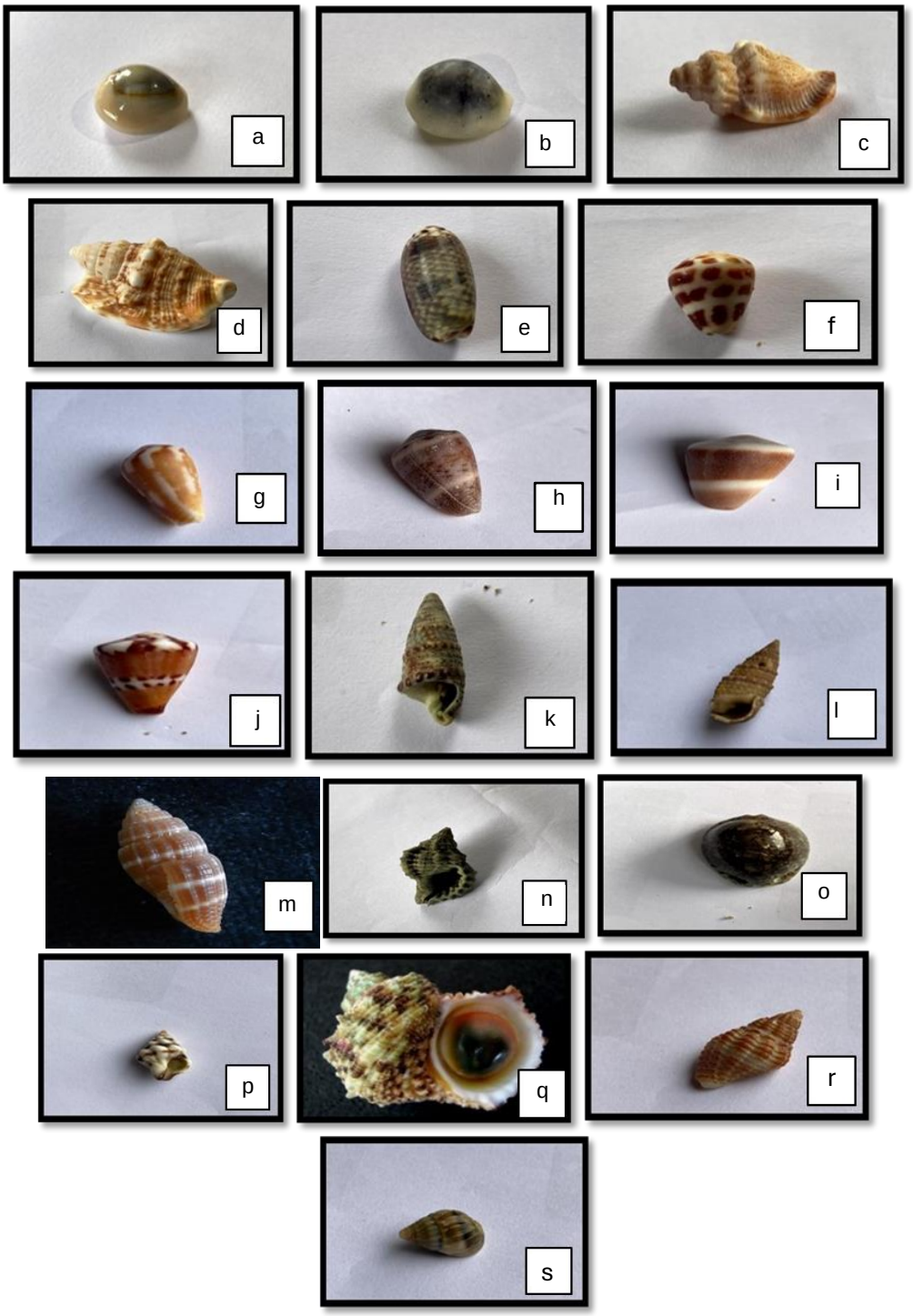

Figure 2 (a) *Monetaria annulus*, (b) *Crypea moneta*, (c) *Strombus alatus*, (d) *Lobatus raninus*, (e) *Olive sericeae*, (f) *Conus ebraeus,* (g) *Conus magus,* (h) *Conus coronatus,* (i) *Conus lividus* , (j) *Conus generalis,* (k) *Ceritium vulgatum*, (l) *Cerithium muscarum*, (m) *Vexillum virgo*, (n) *Morula margariticola*, (o) *Mauritia arabica*, (p) *Peristernia chlorostoma,* (q) *Turbo chrysostomus,* (r) *Solenosteira cancellaria*, and (s) *Nassarius* sp.

rounded oval-shaped body with blunt protrusions all over its surface and a hard-textured body. Living in coastal areas, especially around mangrove forests.

- ***Cerithium muscarum*:** exhibits conical body characteristics; the shell surface is non-uniform and sharp, brown in color, and slightly white in color (Figure 2l). The habitat of this species is a sandy substrate. This species has a tapered body shape, brownish-yellow color, and sharp shell (Ahmad 2018).
- ***Vexillum virgo*:** is found because of its non-uniform

and booky shell surface and brownish-white shell color (Figure 2m), occupying habitats on rocky substrates. This species has a whitish or yellowish shell and is in the form of a sturdy short cone around the top. The size of the shell varied between 13 mm and 25 mm (Ahmad 2018.

- ***Morula margariticola*:** is blackish brown with an ununiform and rough shell surface (Figure 2n) and is found on sandy, rocky, and rocky sandy substrates. Ba sed on previous studies, this species has an oval-shaped shell and bulges in its whorl body, and the surface of the shell is black and found on rock substrates (Alita 2021).

- ***Mauritia arabica*:** has a smooth shell surface and a brown batik pattern on the shell (Figure 12o), obtained on substrates with rocks and sand. This species has an egg-shaped shell, generally has a bluish-black color, and a brown fine line pattern. It is usually found under rocks (Alita 2021).

- ***Peristernia chlorostoma*:** has a non-uniform and rough shell surface that is white in color with a blackish tinge on the shell surface. (Figure 2p). The habitat of this species is rocky, has a shell with a black box pattern and a corrugated shell surface. This species can also be found in rocks (Ahmad 2018).

- ***Turbo chrysostomus*:** has a non-uniform, sharp shell, and is brownish yellow in color. (Figure 2q) and is a species of gastropod found on rocky substrates. This species is anteroposterior in length (height), exceeding its width, and has a light brown color interspersed with brown and spiral green stripes that have thorns found in coral rocks (Alita 2021).

- ***Solenosteira cancellaria*:** exhibits a rough and non-uniform shell surface characteristic; the shell is brown and slightly whitish (Figure 2r) and is found on sandy and rocky substrates. Based on the literature, the species has a shell size ranging from 10 to 20 mm, a jagged shell, and is brownish yellow (Ahmad 2018).

- ***Nassarius* sp.:** has a non-uniform shell surface of dark ash color. Circular gray lines on the shell (Figure 2s). *Nassarius sp.* is found on sandy and rocky sandy substrates. This species has a brownish-black shell and a pointed shell tip and can be found in both sandy and rocky habitats (Ahmad 2018).

CONCLUSION

There were 19 types of gastropods found on Telindale Beach with a Gastropod Diversity Index (*H'*) of 2.84. Based on the species diversity index, it indicates that coastal waters are lightly polluted. The implications of such water conditions can damage the seawater ecosystem and disrupt existing biota.

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