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DIVERSITY AND ABUNDANCE OF PLANKTON FROM PEUNAGA, CUT UJONG ESTUARY, MEULABOH, WEST ACEH

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ABSTRACT

The research aims to determine the structure of the plankton community in the waters of Gampong Peunaga Cut Ujong, Meureubo, Meulaboh, West Aceh. The study was conducted in September 2023. The collection point consisted of 3 stations, and sampling was carried out at high tide with three repetitions. The filtering process uses a plankton net with a mesh size of 30 µm. Phytoplankton at the research location consists of five classes, namely Cyanophyceae, Euglenophyceae, Chlorophyceae, Bacillariophyceae, and Dinophyceae. Meanwhile, zooplankton consists of 7 groups consisting of Protozoa, Rotifera, Crustacea, Polychaeta, Gastropoda, Pelecypoda, and Nematoda. Phytoplankton has the highest percentage in the Bacillariophyceae class, reaching 71.7%, and the lowest <1% (Dinophyceae, Euglenophyceae, and Chlorophyceae). The abundance of phytoplankton at station three during the study ranged between 2,025,600 cells/m^3 - 6,710,400 cells/m^3 and zooplankton in the range of 23,400 ind/m^3 - 33,480 ind/m^3. The average diversity index (H') for phytoplankton was 1.04, the uniformity index (E) was 0.40, and the dominance index (C) was 0.50. Meanwhile, zooplankton has values H' (1.42), E (0.65), and D (0.36). To maintain the Peunaga estuary area as an ideal buffer area, it is recommended to regularly monitor the community structure of aquatic biota (plankton, benthos, and fish).

***Keywords**: buffer ecosystem, community structure, dominance index, Navicula sp.*

INTRODUCTION

Estuarine waters are productive ecosystems influenced by anthropogenic pressure (Santos *et al.,* 2022) and are transitional ecosystems (Bharathi *et al.,* 2022; Venkataramana *et al.,* 2023). Estuarine waters are vulnerable to environmental changes (Soetignya *et al.,* 2021). Plankton has relatively passive movements (Abdus *et al.,* 2021) and is one of the fundamental parts of water (Najmi *et al.,* 2022). This is because one of its constituents, namely phytoplankton, is a crucial element for assessing the status of ecological quality (Santos *et al.,* 2022) and has an essential role as the primary producer of estuarine ecosystems (Steidle & Vennell, 2023). Meanwhile, zooplankton is a trophic link in energy transfer from primary producers to secondary consumers (Venkataramana *et al.,* 2023). Other roles of zooplankton can influence pelagic fish's potential emergence and distribution (Hastuti *et al.,* 2018). The formation and spatial distribution of phytoplankton abundance in estuaries are controlled by (1) local mechanisms, which determine the balance of water column production losses at specific spatial locations (controlling abundance), and (2) transport related mechanisms, which regulate biomass distribution (i.e., controlling abundance) (Luke *et al.,* 1999). The abundance of phytoplankton and zooplankton is related to the mangrove ecosystem, and mangrove damage can harm the diversity of phytoplankton and zooplankton (Hilmi *et al.,* 2020).

Apart from having a function for ecology, plankton can be used as an excellent indicator of the status of ecosystems and fisheries because of their essential role in marine food webs and their core values in integrated ecosystem assessments (Bi *et al.,* 2022). Phytoplankton can also be used as a bioindicator to assess water pollution (Lathifah *et al.,* 2021). From an industrial perspective, phytoplankton species have been used as raw materials for various benefits, namely wastewater treatment, production of high-value compounds, and commercial products, such as food and feed supplements, pharmacological compounds, lipids, enzymes, biomass, polymers, toxins, pigments (Souza *et al.,* 2022). The structure of the phytoplankton community in the upper estuary with low salinity is dominated by green algae and diatoms; in the middle estuary area with moderate salinity, there are abundant diatoms and blue-green algae, while in the high estuary with low salinity, the presence of diatoms is very prominent (Bharathi *et al.,* 2022). Research reports indicate that zooplankton diversity and abundance are mainly determined by salinity rather than phytoplankton biomass (chlorophyll-a) in Indian estuaries during post-monsoon (Venkataramana *et al.,* 2023). Zooplankton in estuaries also shows differences in lower and upper zones in community function in these waters (Sanvicente-Añorve *et al.,* 2022). Monitoring zooplankton types is very important in estuarine waters because Zheng *et al.* (2022) stated that the biodiversity and functional stability of zooplankton in estuarine waters have essential implications for conservation strategies.

Gampong Peunaga Cut Ujong, Meureubo, and West Aceh waters are relatively small estuaries but have an essential role in the surrounding ecosystem. In 2022, the edge of the estuary will be planted with mangroves to avoid abrasion and maintain the ecology around the estuary. This estuary has a strategic role as a transition area between land and sea that supports both. Information about research locations related to the diversity of aquatic biota has never been carried out. Therefore, it is necessary to provide information about plankton community structure to know water productivity for further management in the Gampong Peunaga Cut Ujong estuary, Meurebo, West Aceh.

MATERIAL AND METHODE

Study area

This research was carried out on the coast of Gampong Peunaga Cut Ujong, Meurebo District, West Aceh Regency (**Figure 1**). The sampling point consists of 3 stations, including the part close to the coast, the middle, and the part towards the mainland.

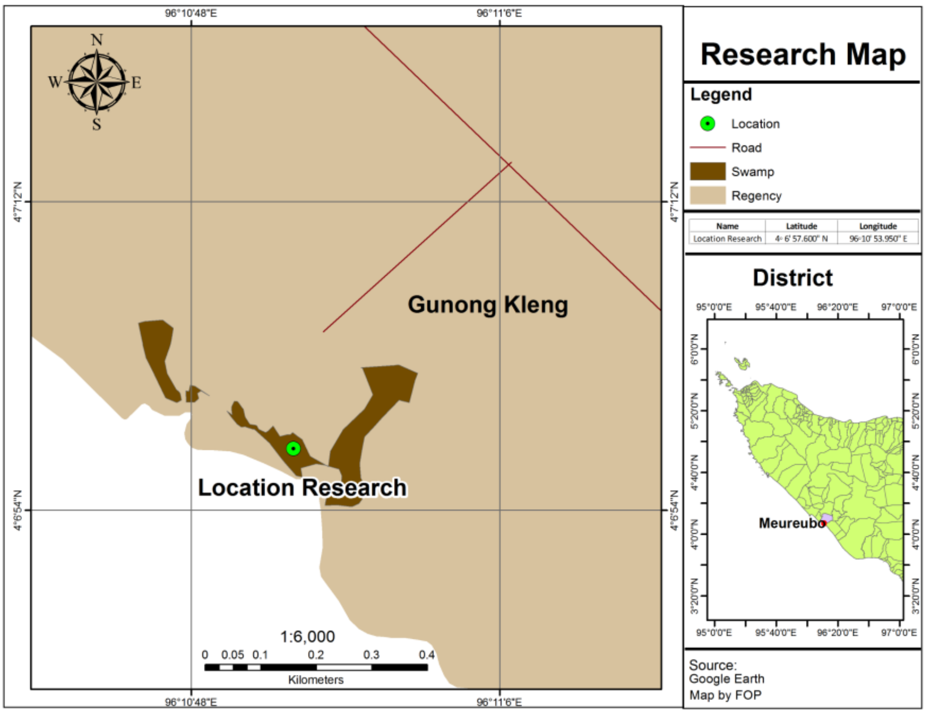

Figure 1. Map showing the location (the green dot) of Gampong Peunaga Cut Ujong Meureubo, West Aceh

Plankton sampling and identification

The research was conducted in September 2023. The sampling technique used purposive sampling by determining predetermined points to represent the research location. The filtering process uses a plankton net with a mesh size of 30 µm. Plankton sampling was carried out at high tide with three repetitions. Plankton filtering is carried out with 100 liters, and the filter yield is 100 ml. Sample preservation was carried out by applying Lugol to the sample until it turned brownish-yellow. Next, the samples were tested at the Environmental Productivity Laboratory, Department of Aquatic Resources Management, Faculty of Fisheries and Maritime Affairs, IPB University, using an Olympus CX 23 microscope. Plankton identification refers to Yamaji (1979). Plankton identification is carried out down to the lowest group. The diversity index (H') and evenness (E) are determined based on the Shannon-Wianer Index, and the Simpson index approximates the dominance (D) index. The water quality parameters measured are temperature, salinity, pH, and DO. The tools used are a thermometer, refractometer, DO meter, and pH pen. Water sample measurements were carried out during sampling with three repetitions.

RESULTS AND DISCUSSION

Plankton composition

The research showed that plankton (phytoplankton and zooplankton) varied with varying genera at each station. Phytoplankton at the research location consists of five groups (*Cyanophyceae*, *Euglenophyceae*, *Chlorophyceae*, *Bacillariophyceae*, and *Dinophyceae*) composed of 30 genera. The Cyanophyceae group consists of four genera: Euglenophyceae (one genera), Chlorophyceae (three genera), Bacillariophyceae (19 genera), and Dinophyceae (three genera). Zooplankton comprises seven groups (Protozoa, Rotifera, Crustacea, Polychaeta, Gastropoda, Pelecypoda, and Nematoda) with 18 genera. The Protozoa group consists of 8 genera, four genera of Rotifera, two genera of Crustacea, and for the Polychaeta, Gastropoda, Pelecypoda, and Nematoda groups, the presence of phytoplankton and zooplankton, by genus and observation station is presented in **Table 1** and **Table 2**.

Tabel 1. The presence of phytoplankton in waters Gampong Peunaga Cut Ujong estuary, West Aceh

Species	P.1.a	P.1.b	P.1.c	P.2.a	P.2.b	P.2.c	P.3.a	P.3.b	P.3.c
					CYANOPHYCEAE				
Anabaena sp.	+	+	+	+	+	+	+	-	+
Chroococcus sp.	+	-	-	-	-	-	-	-	-
Lyngbya sp.	-	+	-	-	-	-	+	-	-
Trichodesmium sp.	+	-	+	+	+	-	+	+	+
					EUGLENOPHYCEAE				
Euglena sp.	+	+	+	+	+	+	+	+	+
					CHLOROPHYCEAE				
Closterium sp.	-	-	+	-	-	-	-	-	-
Netrium sp.	-	-	-	-	-	-	-	-	+
Spirogyra sp.	-	-	-	-	-	-	-	+	-
					BACILLARIOPHYCEAE				
Achnanthes sp.	-	-	+	+	-	-	+	-	+
Amphiprora sp.	+	-	+	-	-	-	+	+	+
Amphora sp.	+	+	+	-	+	-	+	+	+
Bacillaria sp.	-	-	+	-	-	-	+	+	+
Chaetoceros sp.	+	+	+	-	+	-	-	+	-
Cocconeis sp.	+	-	+	+	+	-	+	-	+
Coscinodiscus sp.	-	-	-	-	-	-	-	-	-
Cyclotella sp.	-	-	-	+	-	-	-	-	-
Eunotia sp.	-	-	-	-	+	-	-	-	-
Fragilaria sp.	-	-	-	-	+	-	+	+	-
Frustulia sp.	+	-	-	-	-	-	+	-	-
Gomphonema sp.	-	-	-	-	+	-	-	-	-
Melosira sp.	+	-	-	+	+	+	+	+	+
Mostogloia sp.	+	-	+	+	+	+	+	-	+
Navicula sp.	+	+	+	+	+	+	+	+	+
Neidium sp.	-	+	+	-	+	-	-	-	-
Nitzschia sp	+	-	+	+	+	-	+	+	+
Pinnularia sp.	-	-	-	-	+	-	+	+	-
Pleurosigma sp.	+	+	+	+	+	+	+	+	+

Species	P.1.a	P.1.b	P.1.c	P.2.a	P.2.b	P.2.c	P.3.a	P.3.b	P.3.c
				DINOPHYCEAE					
Ceratium sp.	-	-	+	-	-	-	-	-	-
Glenodinium sp.	-	-	-	-	-	+	-	+	-
Peridinium sp.	+	+	+	+	+	+	-	-	-

Description: P.1= Station 1, P.2= Station 2, P.3 Station 3, a=repetition 1, B=repetition 2 and c=repetition 3, (+) = found, (-) = not found

Cyanophyceae (*Anabaena* sp. and *Trichodesmium* sp.) were found at all stations. Genus *Lyngbya* sp. was only found at two stations, namely stations 1 and 3, while *Chroococcus* sp. was only found at station 1. Class Euglenophyceae (*Euglena* sp.) was found at all stations. Meanwhile, the Chlorophyceae class (*Closterium* sp., *Netrium* sp., *Spirogyra* sp.) at the research location was only found at 1 station each. Three genera of Dinophyceae were found, and all three were only found at 1 station (*Ceratium* sp.); *Glenodinium* sp. and Peridinium sp. were found at station two. The largest class found at the research location was Bacillatiophyceae. This group has 18 genera, with the types of genera found in all stations being *Achnanthes* sp., *Amphora* sp., *Chaetoceros* sp., *Cocconeis* sp., *Melosira* sp., *Mostogloia* sp., *Navicula* sp., *Neidium* sp., *Nitzchia* sp., *Pinnularia* sp., and *Pleurosigma* sp. The other eight genera were only found at 1 or 2 observation stations. The Bacillariophyceae class is a class found with a high level of presence at research stations. This condition is also the same in the Mond River Estuary, Iran (Pouladi *et al.,* 2017); the Donan River Estuary, Cilacap, Indonesia (Pratiwi *et al.,* 2018); and Musi Muara, South Sumatra (Apri *et al.,* 2021). The presence of Bacillariophycea partly dominates the phytoplankton in estuaries, but each estuary has certain types that are abundant. For example, in the estuary of the research location, the genera that were more commonly found were *Navicula* sp. Meanwhile, if the estuary is around the mangrove ecosystem, it will be dominated by the Skeletonema genera (Rozirwan *et al.,* 2022).

Table 2. The presence of zooplankton in waters of Gampong Peunaga Cut, Aceh Barat

Genus	P.1.a	P.1.b	P.1.c	P.2.a	P.2.b	P.2.c	P.3.a	P.3.b	P.3.c
				PROTOZOA					
Arcella sp.	-	+	-	+	+	+	+	-	+
Class of Ciliata (sp1)	+	+	-	-	+	+	+	+	-
Didinium sp.	+	+	+	-	-	+	-	-	-
Difflugia sp.	-	+	-	-	+	-	-	+	-
Eutintinnus sp.	+	+	+	+	+	+	+	+	-
Tintinnopsis sp.	+	+	+	-	+	+	-	-	-
Vorticella sp.	+	+	+	-	+	-	+	-	-
Wailesella sp.	-	-	-	+	-	-	-	+	-
				ROTIFERA					
Brachionus sp.	+	+	+	+	+	+	+	+	+
Colurella sp.	-	-	-	+	-	-	-	-	-
Philodina sp.	-	-	-	+	+	-	-	-	-
Trichocerca sp.	-	-	-	-	-	-	-	+	+
				CRUSTACEAE					
Nauplius (stadia)	+	+	+	+	-	+	-	-	+
Oithona sp.	+	+	+	-	-	-	-	-	-
				POLYCHAETA					
Larvae of Polychaeta (sp1)	+	+	+	-	+	+	-	-	+
				GASTROPODA					
Larvae of Gastropoda (sp1)	+	+	+	+	+	+	-	+	-
				PELECYPODA					
Larvae of Pelecypoda (sp1)	+	+	-	+	-	-	-	-	-
				NEMATODA					
Nematoda Worm (sp1)	-	-	+	+	+	+	+	+	+

Description: P.1= Station 1, P.2= Station 2, P.3 Station 3, a=repetition 1, B=repetition 2 and c=repetition 3, (+) = found, (-) = not found

From the protozoan groups found at all stations, Zooplankton at the research location is *Arcella* sp., Ciliata class (sp.1), *Eutintinnus* sp. Meanwhile, *Didinium* sp., *Difflugia* sp., *Tintinnopsis* sp., *Tintinnopsis* sp., *Vorticella* sp., and *Wailesella* sp. were only found at one station or two stations. The next Phylum is Rotifera, with the type *Brachionus* sp.

(Eurotatoria class) found at all stations. Still, Nauplius stages, Polychaeta larvae, Gastropoda larvae, and Nematoda were found only at one station each. Eurotatoria class other than *Brachionus* sp. also *Colurella* sp., *Philodina* sp., and *Trichocerca* sp.. In the crustacean class, nauplius (stadia) was found at all stations, and *Oithona* sp was found at two stations. The research location also found the polychaete, gastropod, pelecypods, and nematoda phyla classes. Phylum Rotifera was found at all stations, and all repetitions were engaging because rotifers, especially *Brachionus* sp., are one of the natural feeds for several fish cultivation commodities. It was stated by Cleetus *et al.* (2015) that Rotifers are an integral part of the food chain and a link between nanoplankton and carnivorous zooplankton. The diversity of this group is also an indication of aquatic ecological factors and a sensitive indicator of changes in water quality. Small rotifers in water can also be used as initial food for marine fish (Lahore *et al.,* 2013).

Abundance and Community Structure

The research results show that the phytoplankton group is more abundant than the other groups (**Figure 2**). The percentage of the Bacillariophyceae class reached 71.7% and Cyanophyceae 27.2%, while the other three groups only had less than 1% (Dinophyceae, Euglenophyceae, and Chlorophyceae). The Bacillariophyceae class with the highest average was *Navicula* sp., up to 1,923,467 cells/m^3, around 66.6% of the total Bacillariophyceae. The second highest abundance was the Cyanophyceae group, with an average report of 571,400 cells/m^3 during the study. The lowest average abundance reported was 267 cells/m^3 consisting of *Closterium* sp. (Chlorophyceae), *Cyclotella* sp., *Eunotia* sp., *Gomphonema* sp. (Bacillariophyceae), and *Ceratium* sp. (Dinophyceae).

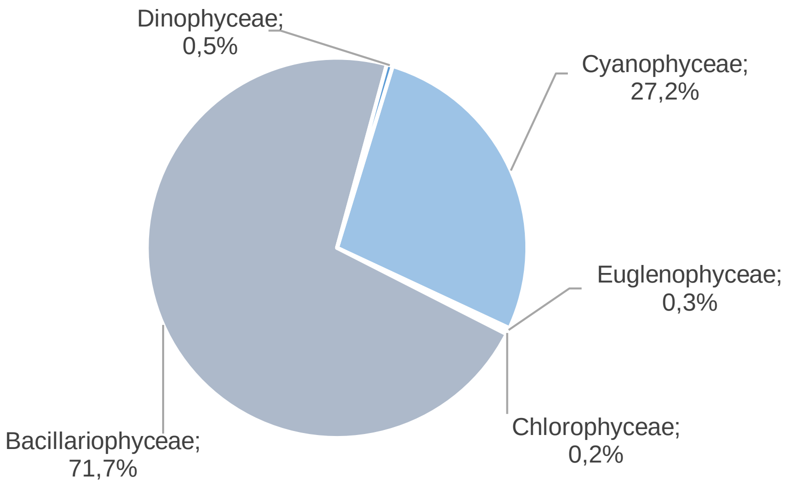

Figure 2. Composition and abundance of phytoplankton in Gampong Peunaga Cut Ujong, Meurebo, West Aceh

The Euglenophyceae group with the genus Euglena was found at all stations with an average number of 9,333 cells/m^3. The Chlorophyceae class with each genus is only found at one station, although in general, according to (Bendtsen *et al.,* 2023), this class is green algae, which has a wide distribution in fresh and salt waters. The highest average abundance was *Spirogyra* sp. (5,600 cells/m^3), while the lowest was found in *Closterium* sp., stating only 267 cells/m^3. The type of *Netrium* sp. (800 cells/m^3) was found in more significant numbers than *Closterium* sp. *Netrium* sp., including green algae, has been reported to be found in the waters of the Krueng estuary in Aceh with a report of 2562,170 ind/l (Jannah *et al.,* 2012). The research results for the Cyanophyceae class have the second highest opinion after Bacillariophyceae. The Dinophyceae group with the highest reporting rate is *Peridinium* sp. (10,400 cells/m^3), and the lowest average is *Ceratium* sp. (267 cells/m^3). Dinophyceae is a diverse group of unicellular organisms. Most have double flagella and swim freely (Salmaso & Tolotti, 2008). The Dinophyceae class is a group of phytoplankton that plays a vital role as primary producers in waters. However, in very abundant conditions, it can endanger ecosystems and aquatic biota (Herawati *et al.,* 2023).

The variety of genera from the Bacillariophyceae group strengthens the statement that in waters experiencing tidal waters, Bacillariophyceae show that the biomass and reports are higher (Cereja *et al.,* 2021). The highest abundance in *Navicula* sp., which, according to Yang *et al. (*2023), can play a role in the widespread carbon cycle in water bodies, making it a primary producer that serves a vital role for global carbon neutrality. The distribution and say of phytoplankton will influence this as a helpful tool for assessing and monitoring estuarine ecosystems (Patel & Sahoo, 2021). However, an unbalanced species distribution can indicate ecosystem instability on the coastline due to surrounding activities (Abdus *et al.,* 2021).

Research results show that the percentage of zooplankton with the most significant value is the Rotifera group, which is≥48%. Meanwhile, the lowest delivery was in the Pelecypoda class, ≤0.4%. Phylum Rotifera is composed of 4 genera: *Brachionus* sp., *Colurella* sp., *Philodina* sp., and *Trichocerca* sp.. based on these four groups, *Brachionus* sp. has a percentage of up to 47.9%. By reporting an average during the study of 41,840 ind/m^3. Meanwhile, the lowest figure with a value of 80 ind/m^3 was the reporting of *Colurella* sp. Protozoa had eight genera during the research and reported 20,000 ind/m^3, with the highest reporting being the *Eutintinnus* sp. (8,120 ind/m^3). The lowest reporting was found in *Difflugia* sp. and *Wailesella* sp.; both have respective reports of (240 ind/m^3). Apart from the phyla Rotifera and Protozoa, the third largest group is the gastropod class, with a 9,280 ind/m^3 report. The height states *Brachionus* sp. allegedly because the food source for *Brachionus* sp is available in the waters. Strengthened by the results of previous research reporting that *Brachionus calyciflorus* eats preferred algae (*Cyclotella* sp, *Scenedesmus opoliensis*) (Pagano, 2008).

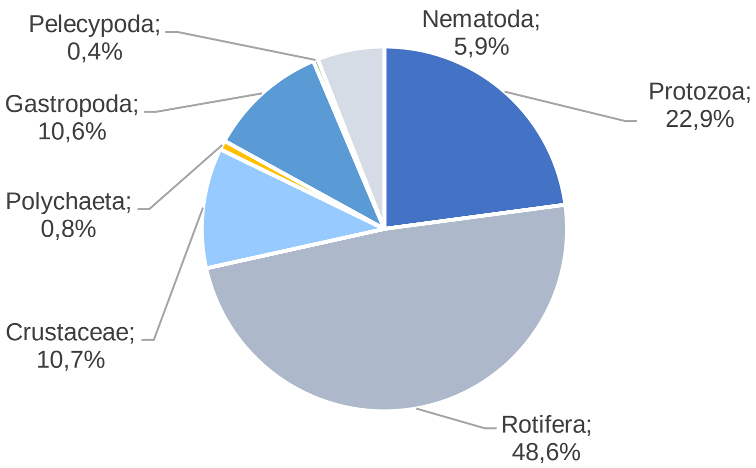

Figure 3. Composition and abundance of zooplankton in Gampong Peunaga Cut Ujong, Meurebo, West Aceh

The total average abundance shows that the third station has higher phytoplankton coverage than the other stations, but zooplankton coverage is also lower than the other stations. The abundance of phytoplankton at station three during the study ranged between 2,025,600 cells/m^3- 6,710,400 cells/m^3 and zooplankton in the range of 23,400 ind/m^3 - 33,480 ind/m^3. The range of phytoplankton and zooplankton at station 1 is 662,400 cells/m^3 - 2,282,400 cells/m^3 and 77,040 cells/m^3 - 190,440 cells/m^3, and station two is 309,600 cells/m^3 - 3,705,600 cells/m^3 and 59,760 cells/m^3 -100,800 ind/m^3. Generally, the third station reports phytoplankton P3>P2>P1 while zooplankton P1>P2>P3. Phytoplankton abundance, when compared between stations, illustrates varying emissions. Based on the research results, it is stated that phytoplankton influences the rate of primary productivity, which, according to Kusdaryanti & Rosada (2018), describes a quantitative picture of suburban waters. This is because phytoplankton function as primary producers (Darmarini *et al.,* 2021), and primary productivity is closely related to phytoplankton reporting (Nurfadillah *et al.,* 2019).

Community structure

The total average abundance of phytoplankton and zooplankton for each station, diversity, uniformity, and dominance indices at each station during the study are presented in **Table 3**. The total average value recorded during the phytoplankton study (2,883,733 cells)/m^3) and zooplankton (87,400 ind/m^3). The average diversity index (H') for phytoplankton is 1.04, the uniformity index (E) is 0.40, and the dominance index (D) is 0.50. Meanwhile, the average total value of zooplankton has values of H' (1.42), E (0.65), and D (0.36). This shows that the H' value has a low value, namely ≤ 1 for phytoplankton, with a uniformity index of 0.40 and a dominance index of 0.50. Meanwhile, zooplankton has an H' value of 1.4, a uniformity index of 0.65, and a dominance index of 0.36. The H' value at the research location describes plankton diversity in low water. Low H' indicates that the ability of phytoplankton to use tolerance capabilities in the environment is still lacking, so only specific genera are abundant (Odum, 1993).

Table 3. Average diversity index (H), uniformity index (E), and dominance index (C) at each station at the Gampong Peunaga, Cut Ujong estuary, West Aceh

Parameter/Station	Phytoplankton*			Zooplankton**		
	Station 1	Station 2	Station 3	Station 1	Station 2	Station 3
Number of taxa (S)	14	12	15	11	10	7
Total abundance	1.418.400	2.013.600	5.219.200	149.760	84.000	28.440
Diversity index (H')	1,08	0,95	1,10	1,81	1,11	1,35
Evenness index (E)	0,42	0,39	0,40	0,75	0,48	0,71
Dominance index (C)	0,49	0,53	0,49	0,22	0,52	0,34

Description: * = (cell/m^3), ** = (ind/m^3)

The average dominance index for phytoplankton describes the presence of species that tend to dominate (C=0.5). At the same time, for zooplankton, it has a value of 0.4, which means it is close to the value of dominance tendency. The structure of the plankton community in the waters of Gampong Peunaga Cut Ujong must receive attention because the area is a link between land and sea, so residential, business, and other activities will affect water conditions. Nutritional mutations and the presence of zooplankton can cause the tendency for inevitable phytoplankton dominance. This trend is likely due to the presence of zooplankton at the research location. This is because it states that phytoplankton is influenced by zooplankton. The relationship between the two influences each other, as Najmi *et al.* (2022) explained that the presence of zooplankton influences the presence of phytoplankton. Bendtsen *et al.* (2023) added that the composition of the phytoplankton community is essential in shaping ecosystem structure and function. The structure of the plankton community at the research location is vital to carry out sustainably; this is because, based on research results (Yang *et al.,* 2023), it is stated that phytoplankton and microzooplankton play an essential role in the ecosystem, which responds first to environmental changes. Further, the fundamental mechanisms that form communities help improve ecosystem function. At the research location in the substrate area, several identified benthos was found, namely Polychaeta (*Nereis* sp.), Gastropods (*Faunus* sp. and *Neritina* sp.), Pelecypoda (*Corbula* sp., *Crassostrea* sp.). Benthos at the research location is also essential in the estuary food chain cycle. This group is also an organism that can determine the reported health status of estuarine ecosystems (Irham *et al.,* 2012) and how habitat conditions influence its diversity (Darmarini *et al.,* 2021). Air quality analysis, including temperature, pH, salinity, and DO, was carried out at the research location. The results of air quality measurements vary at stations 1, 2, and 3. The results of DO measurements at the research location have values between 3.75-4.50, a temperature range of 29.80-29.84°C, salinity is 0.65 to 1.37, and pH is 6.85-7.01. The water quality parameters of the research location are thought to be something that influences the presence of plankton at that location. In their research results, Meiriyani *et al.,* (2011) stated that nitrate and DO affect phytoplankton.

CONCLUSIONS AND RECOMMENDATIONS

The research location is a vital buffer ecosystem between sea and land. The presence of phytoplankton and zooplankton at each station varies greatly. The community structure built based on research results shows a low diversity index for phytoplankton and a medium for zooplankton. There are more Bacillariophyceae classes than other phytoplankton classes, while zooplankton has more diverse types originating from the rotifers group. The dominance index at several stations tends to approach the value of 0.5. In managing the Peunaga estuary area, it is recommended to periodically monitor the community structure of aquatic biota (plankton, benthos, and fish).

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