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Diversity of epipelic microalgae in a shallow, tropical estuary of Northern Mindanao, Philippines

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Abstract. *Tucong EJA, Tubio EG, Leopardas VE. 2024. Diversity of epipelic microalgae in a shallow, tropical estuary of Northern Mindanao, Philippines. Biodiversitas 25: 3237-3245.* Microphytobenthos are important primary producers in many of the most critical ecosystems, including the estuary. However, environmental variables, including season, influenced their abundance and diversity. In this study, spatial and temporal patterns of epipelic microalgae in Talabaan Estuary Naawan, Misamis Oriental, were conducted last October 2016 and February 2017 to represent wet and dry seasons, respectively. The species composition and diversity of epipelic microalgae samples were assessed using an improvised corer (2 cm, inner diameter). Only the upper 10 mm. of the cored sample was analyzed. Forty-eight species belonging to 33 families and 35 genera were identified and documented in the estuary. Diatoms (Class Bacillariophyta) were found to be the most dominant group, with about 90% of the epipelic microalgae community composed mainly of chains of cells and formed in colonies. *Navicula* sp. and *Nitzschia* sp. were among the species found in all sampled stations. The common occurrence of this species across all stations in wet and dry seasons indicated that they are the typical euryhaline species of this tropical estuary. The abundance and diversity of the epipelic microalgae community were found to vary across stations and seasons ($p<0.05$), but the interaction between these variables did not differ significantly. When abiotic and biological factors were regressed, a significant relationship was found with temperature, while all other factors exhibited no considerable variation. This highlights the effect of seasons in shaping benthic microalgae communities and is an essential factor in structuring microphytobenthic communities in an estuary.

Keywords: Algae, diatoms, dry season, Talabaan estuary, wet season

INTRODUCTION

Estuaries are dynamic transitional zones where freshwater from rivers mixes with saltwater from the ocean (Schubert and Telesh 2017). These environments are characterized by salinity level fluctuation, tidal influences, and complex sediment dynamics, making them highly diverse and productive ecosystems (Testa et al. 2018; Tweedley et al. 2019). Estuaries are also crucial in nutrient transformation and primary productivity (Douglas et al. 2022). They are home to a diverse range of species vital for the economy, serving as a source of food, minerals, and energy (Mitra et al. 2016). Among these diverse organisms are microphytobenthic taxa (MPB), comprising various microalgae and cyanobacteria residing within estuarine sediments (Croce et al. 2021). They are essential primary producers and are crucial in nutrient cycling, sediment stabilization, and overall ecosystem functioning (Hope et al. 2020; Serôdio et al. 2022; Plante et al. 2023). Due to their short generation lives, they can respond quickly to changing environmental conditions (Yong et al. 2016), making them one important key in sustaining higher trophic levels and serving as good bioindicators of estuarine health (Lemley et al. 2016; Pennesi and Danovaro 2017).

Microalgal abundance and distribution in estuaries are highly affected by environmental conditions, including the biotic and abiotic components (Tsuji and Montani 2017; Ribeiro et al. 2021). For instance, sediment type influences microphytobenthos distribution in estuaries. Sandy sediments were found to support higher biomass of MPB with active vertical transport mechanisms, contrasting with limited distribution in muddy sediments (Yin et al. 2016). Meanwhile, a mixture of sand and mud shows better biomass and photosynthetic performances than pure sand or mud (Morelle et al. 2020). This only shows the effect of sediment characteristics on the composition and abundance of microphytobenthic communities. Microphytobenthos in estuaries are also influenced by wind and tides, with the wind playing a dominant role in shallow areas and tides in deeper sections (Diez-Minguito et al. 2023).

MPB (Microphytobenthic taxa) abundance and distribution vary seasonally in estuaries, with higher biomass and net production towards the sea, influenced by environmental factors like light and temperature (Haro et al. 2020). While general patterns of seasonality in microphytobenthic taxa exist across estuaries worldwide (Frankenbach et al. 2020; Ribeiro et al. 2021; Zhang et al. 2021), local factors such as hydrology, sediment characteristics, and nutrient inputs profoundly influence the dynamics of microalgal populations (Aneesh et al. 2015; Rojo et al. 2016; Cotiyane et al. 2019). Thus, understanding the seasonal variations in microalgal assemblage in estuaries provides crucial insights into the local-scale processes governing estuarine ecology, expands our understanding of the spatial variability in seasonal patterns of microalgal communities, and provides comparative insights across different geographic regions.

In Southern Philippines, specifically in Naawan, Misamis Oriental, lies the Talabaan estuary, which plays a significant role as a central drainage system for the municipality. It receives runoff from adjacent terrestrial environments, carrying nutrients, sediments, and organic matter into the estuarine ecosystem. Estuaries then support diverse fauna and flora and provide essential habitats for many species. Despite its ecological importance, the Talabaan estuary is relatively under-studied, particularly regarding its microphytobenthic communities. As a result, there is an urgent need to bridge the gap in understanding the composition, distribution, and ecological role of microphytobenthic communities, especially epipelic microalgae. This does not only apply to the Talabaan estuary; in general, microalgae research still needs to be improved in the estuaries of the Southern Philippines, including Northern Mindanao. This study will provide valuable baseline data and serve as a foundation for future research, conservation initiatives, and sustainable management practices to preserve the ecological integrity of the Talabaan estuary and similar coastal ecosystems.

MATERIALS AND METHODS

Description of the study area

Talabaan Estuary is located in the Municipality of Naawan, Misamis Oriental, Philippines (Figure 1). It lies between 8.4°N; 124.2°E and serves as the major drainage of the locality wherein the rainwater from the mountainous landscape directly flows down to the river and unto Iligan Bay. Its sub-watershed covers seven (7) out of the 10 barangays in the municipality, namely Barangays Poblacion, Don Pedro, Mapulog, Mat-i, Tagbalogo, Patag, and Lubilan. The riverbanks and neighboring areas of the estuary are mostly covered with different vegetation and farmlands. Some parts of the river were subjected to drought sometimes during summer (Municipality of Naawan Comprehensive Land Use Plan 2000).

Three stations were sampled, and three samples per station were collected for microalgal analysis in October 2016 and February 2017 to represent wet and dry seasons, respectively. The exact locations and descriptions for each station are shown in Table 1.

Table 1. GPS locations of sampling points with descriptions for each station

Stations	Coordinates	Description
Station 1	8.43574°N, 124.65505°E 8.43834°N, 124.28664°E 8.43806°N, 124.28658°E	Established at the river mouth, this station is directly affected by the adjacent sea's salinity fluctuations and tidal action.
Station 2	8.43693°N, 124.29113°E 8.43704°N, 124.29120°E 8.43725°N, 124.29123°E	Established near the Naawan bridge and approximately 500 meters from the river mouth. Construction of the bridge is ongoing, and deep excavations were made within the river.
Station 3	8.43689°N, 124.29392°E 8.43662°N, 124.29394°E 8.43044°N, 124.29399°E	Established on the upper part of the river/estuary. Freshwater inputs characterize this station within approximately 1km from the river mouth.

Figure 1. Location of study site in Talabaan River, Nawaan, Misamis Oriental, Philippines

Collection of samples and counting

Three randomly selected sediment samples were collected for each station using a modified corer (with a 2 cm inner diameter), and only the uppermost 10mm layer of the sediment core was used for species identification and quantification (Majewska et al. 2012). The cored sediment samples undergo a decantation process to separate sediment particles, allowing for the isolation of microalgal assemblages. All samples were placed in labeled vials, the volume was fixed to 20 mL, and Lugol's iodine solution was added for preservation. Samples were then brought to MSU at Naawan Microbiology Laboratory for analysis. Microphytobenthic taxa were identified using a compound microscope. Three aliquot samples were analyzed and counted from each collected sample using the Sedgwick rafter-counting chamber.

Physico-chemical parameters

Water temperatures were determined *in situ* using a thermometer (mercury-filled), while a refractometer was used to determine the salinity levels for each sampling station. Nutrient (NO_3 and PO_4) analysis was done using the spectrophotometric method, while sediment organic matter content was determined using the loss-of-ignition (LOI) method.

Data analysis

Diversity indices includes both the species richness and evenness into a single value (Sreekumar 1996) which will be calculated using Shannon-Weiner Index (Odum 1971). Species richness which tells the number of species in the community while species evenness tells how the species abundances are distributed among species.

Shannon-Weiner Diversity Index **(**H') $= -\sum p_i \ln p_i$

Where:

H' : the species diversity (bits ind^{-1})

p_i : the proportion of individuals found in the ith species

Statistical analysis

The statistical analysis was performed using R software. In order to determine whether epipelic microalgae varies across spatial and temporal scales and the interaction of these variables, the Two-Way Analysis of Variance was conducted. To examine the community assemblage pattern, the samples were first visualized in a multivariate cloud using NMDS (Non-metric Multidimensional Scaling) of untransformed abundance data of all species under Bray Curtis similarity index. The patterns observed in the ordinations were statistically tested using Permutational Multivariate Analysis of Variance (PERMANOVA) using the same data set and index.

RESULTS AND DISCUSSION

Species composition and diversity

Forty-eight (48) species of epipelic microalgae belonging to 33 families and 35 genera are identified in the Talabaan estuary in all sampling stations and across seasons. The composition of epipelic microalgae in the estuary is presented in Table 2, while some photographs of the documented species are shown in Figure 2. These microalgal species comprise three major groups, namely diatoms, green algae, and blue-green algae, wherein diatoms (Class Bacillariophyceae) dominate the area, comprising about 90% of all the identified species.

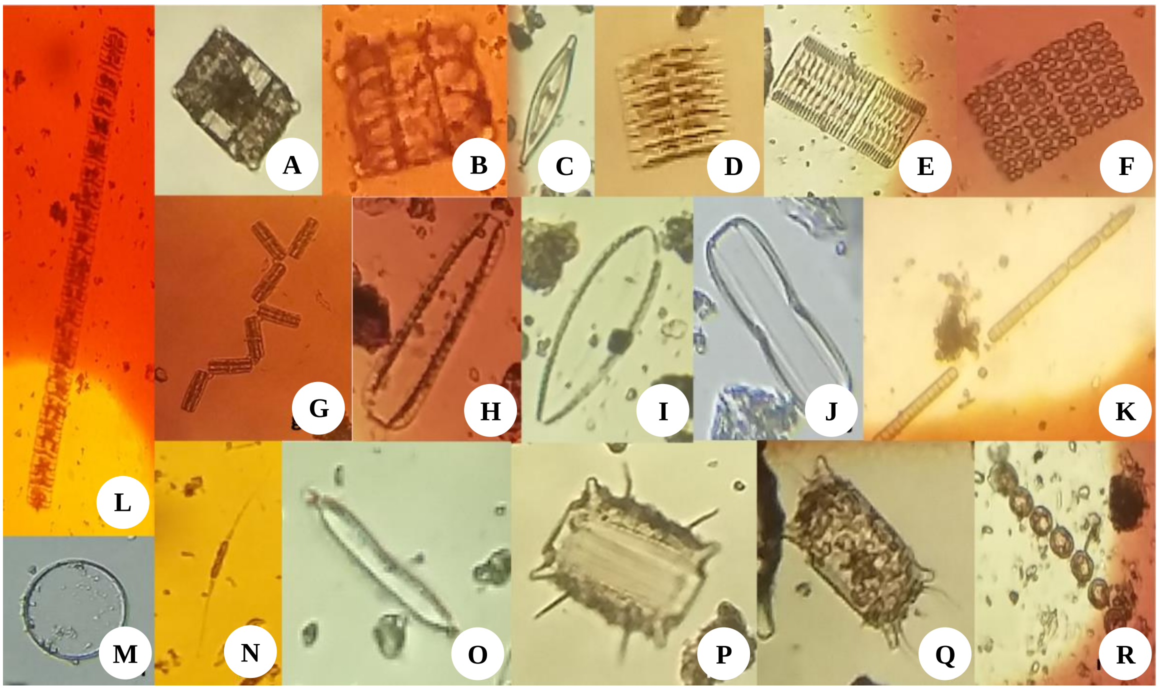

Figure 2. Some of the identified and documented species of epipelic microalgae in Talabaan Estuary, Philippines. A-B. *Biddulphia* sp. C. *Navicula* sp. D. *Fragilaria* sp. E. *Rhabdonema* sp. F. *Merismopedia* sp. G. *Grammatophora* sp. H. *Surirella* sp. I. *S. Robusta* J. *Plagiotropis* sp. K. *Phormidium* sp. L. *Achnanthes* sp. M. *Coscinodiscus* sp. N-O. *Nitzschia* sp. P. *Odontella Aurita* Q. *O. Granulata* R. *Melosira* sp.

Table 2. Species composition of epipelic microalgae in Talabaan Estuary, Naawan, Misamis Oriental, Philippines

Family	Species	Wet Season			Dry Season		
		Station 1	**Station 2**	**Station 3**	**Station 1**	**Station 2**	**Station 3**
Diatoms (Bacillariophyta)							
Achnanthaceae	*Achnanthes* sp.	-	-	+	+	-	-
Catenulaceae	*Amphora* sp.	-	+	+	+	+	+
Bacillariaceae	*Nitzschia* sp.1	+	+	+	+	+	+
	Nitzschia sublinearis	-	-	+	-	-	-
	Nitzschia taylorii	-	+	+	-	-	-
	Hantzschia sp.	-	-	+	-	-	-
Bellerocheaceae	*Bellerochea* sp.	+	-	-	-	-	-
Biddulphiaceae	*Biddulphia* sp.	+	-	-	+	-	-
Chaetocerotaceae	*Bacteriastrum* sp.	+	+	-	+	+	-
	Bacteriastrum Cleve 1873	+	-	-	+	-	-
Coscinodiscaceae	*Coscinodiscus granii* Gough 1905	-	+	+	-	-	-
	Coscinodiscus sp.	+	+	-	+	+	+
Cymbellaceae	*Cymbella* sp.	-	-	+	-	-	-
Entomoneidaceae	*Entomoneis* sp.	-	-	-	+	+	-
Eunotiaceae	*Eunotia* sp.	-	-	+	-	-	-
Fragilariaceae	*Asterionella* sp.	-	-	-	+	-	-
	Fragilaria sp.	+	-	+	+	+	-
Gomphonemataceae	*Gomphonema* sp.	+	-	+	-	-	-
Hemiaulaceae	*Climacodium* sp.	+	-	-	-	-	+
Melosiraceae	*Melosira* sp.	+	+	-	+	+	+
Naviculaceae	*Navicula* sp.	+	+	+	+	+	+
Pinnulariaceae	*Pinnularia* sp.	+	-	-	-	-	-
Plagiotropidaceae	*Plagiotropis* sp.	+	+	+	+	-	-
Pleurosigmataceae	*Donkinia* sp.	+	-	-	-	+	-
	Pleurosigma sp.	+	-	-	-	+	+
Rhabdonemataceae	*Rhabdonema* sp.	+	+	-	+	-	+
Rhizosoleniaceae	*Dactyliosolen* sp.	-	-	+	-	-	-
	Rhizosolenia sp.	-	-	-	+	-	-
Rhopalodiaceae	*Epithemia* sp.	-	+	-	-	-	-
Skeletonemataceae	*Skeletonema* sp.	-	-	-	+	+	-
Striatellaceae	*Grammatophora* sp.	+	-	+	-	-	+
Surirellaceae	*Surirella brebissonii* Krammer and Lange-Bertalot 1987	-	-	+	-	-	+
	Surirella robusta Ehrenberg 1840	-	-	+	-	-	-
	Surirella sp.1	-	+	+	+	-	+
Tabellariaceae	*Tabellaria* sp.	+	+	+	-	-	+
Thalassionemataceae	*Thalassionema* sp.	-	-	-	+	+	+
Thalassiosiraceae	*Thalassiosira* sp.	+	+	+	+	+	-
	Thalassiosira oestropii Hasle 1972	+	-	-	-	-	-
Triceratiaceae	*Odontella aurita* Lyngbye 1819	+	-	-	+	+	+
	Odontella granulata (Roper) R.Ross, 1986	+	-	-	-	-	-
	Odontella mobiliensis Bailey 1851	+	-	-	+	-	-
	Odontella rhombus (Ehrenberg) Kützing, 1849	+	-	-	+	-	-
	Odontella sinensis Greville 1866	+	-	-	+	-	-
Green Algae (Chlorophyta)							
Oedogoniaceae	*Oedogonium* sp.	-	+	-	-	-	-
Cladophoraceae	*Rhizoclonium* sp.	-	-	-	-	-	+
Closteriaceae	*Closterium* sp.	-	-	-	+	-	-
Ulotrichaceae	*Ulothrix* sp.	-	+	-	-	-	-
Blue-green Algae (Cyanophyta)							
Oscillatoriaceae	*Phormidium* sp. K	-	+	+	-	-	-
Total no. of species (n=48)		25	17	21	24	14	15

Note: +: indicates the presence of the species, –: indicates the absence of the species along the three sampling stations

A similar pattern is observed in the Northern Gulf of Mexico (Moreira-González et al. 2020) and in Malaysia, wherein diatoms dominated specifically during dry seasons (Hilaluddin et al. 2020). The fact that diatoms form the most dominant groups of benthic microalgae shows that they are well-adapted to estuarine environments. The pennate diatom in the genus *Navicula* and *Nitzschia* was present in all sampling stations and across seasons. The presence of *Nitzschia* in all sampling stations is attributed to its capacity to tolerate and adapt to a broad range of conditions, even in polluted environments (Siregar et al. 2014). The genus *Odontella* was the most represented genus with 5 species, followed by *Nitzschia* and *Surirella* with 3 determined species under the genera (Table 2). Much of the epipelic microalgae community is dominated by pennate diatoms mainly composed of single cells or chains such as *Fragilaria* sp., *Navicula* sp., *Melosira* sp., *Nitzschia* sp., *Rhabdonema* sp., *Thalassiosira* sp., *Odontella* sp., *Odontella aurita* Lyngbye 1819, and *Tabellaria* sp. Meanwhile, a few species, such as *Coscinodiscus granii* Gough 1905, *Bellerochea* sp., *Cymbella* sp., *Dactyliosolen* sp., *Eunotia* sp., *Epithemia* sp., and *Gomphonema* sp., and *Ulothrix* sp. is only observed during the wet season, while *Asterionella* sp., *Closterium* sp., *Entomoneis* sp., *Rhizoclonium* sp., *Rhizosolenia* sp., *Skeletonema* sp., and *Thalassionema* sp. are species that were only observed and occur during the dry season.

Sediments from Talabaan Estuary have a relatively low species richness and abundance of benthic dinoflagellates compared to that of other estuaries from different parts of the globe, including Brazilian regions (Nascimento et al. 2016; Chomérat et al. 2018). These findings agree with previous reports for other brackish water-dominated estuaries, where heavier freshwater inflows tend to favor diatoms, cyanobacteria, and green algae to the detriment of dinoflagellates (Maggi et al. 2017).

The pattern of diversity based on the calculated values of the Shannon Index of General Diversity (H') showed varying trends across space and time (Table 3). The values indicate that species diversity during the wet season is considerably lower compared to the dry season, although the values are not very distant. Much higher values were observed in Pasuran and Sidoarjo, East Java, Indonesia, ranging from 1.43 to 2.61 (Mahmudi et al. 2023). However, they were still categorized as moderate since high species diversity has values of ≥3 (Singh and Saxena 2015). Heavy rainfall and frequent flooding before collection are some observed factors limiting benthic microalgal growth, which may reduce species richness, abundance, and community composition (Snow 2016).

Abundance of epipelic microalgae in Talabaan estuary

Notable variations in dominant species across stations and between wet and dry seasons are evident in the area (Figure 3). In the wet season, station 1 was dominated mainly by *Rhabdonema* sp., with a relative abundance of 58%. The blue-green alga *Phormidium* sp. mostly dominated stations 2 and 3 with relative abundance of 51% and 36%, respectively. During the dry season, the pennate diatom, *Fragilaria* sp., was the dominant species in station 1, with a relative abundance of 38%. Meanwhile, *Melosira* sp. and *Nitzschia* sp. dominated stations 3 and 4 have 41% and 23% relative abundance, respectively. The abundance of epipelic microalgae identified in the study area shows a significant variation across seasons (two-way ANOVA, p<0.05; Table 4) but not with stations and the interaction of both variables (two-way ANOVA, p>0.05).

Table 3. Values of species diversity (H'), species richness (H' max), and evenness (J') of the epipelic microalgae community in Talabaan Estuary, Naawan, Misamis Oriental, Philippines

Stations	Species Richness (H' max)	Species Evenness (J')	Shannon Index of Diversity (H')
Wet Season			
Station 1	8.93	0.52	0.75
Station 2	5.19	0.57	0.66
Station 3	10.23	0.59	0.88
Dry Season			
Station 1	10.25	0.726	0.989
Station 2	5.97	0.721	0.826
Station 3	5.64	0.765	0.852

Table 4. Summary of the results of the two-way ANOVA on the abundance of benthic microalgae across spatial and temporal scales (*indicates significant variation at p<0.05)

Source of Variation	df	Sums of Sqs.	Mean Sqs.	F value	Pr(>F)
Seasons	1	106,876	106,876	6.034	0.0277*
Stations	1	23,320	23,320	1.317	0.2704
Seasons: Stations	1	16,651	16,651	0.940	0.3487
Residuals	14	247,965	17,712		

Microalgae abundance during the dry season is expected to be high as reduced terrestrial runoff during these seasons may have enhanced the productivity of microalgae communities such as pennate diatoms (Essien et al. 2008); however, this was not the case for this study. Compared to the wet season, the dry season's mean abundance of epipelic microalgae was generally low, ranging from 94 to 148 cells mL^{-1}, while the damp season had a mean abundance ranging from 318 to 964 cells mL^{-1} (Figure 4). The same pattern was observed in the Savannah River estuary, where the seasonality of microphytobenthos revealed apparent temporal variations with lower values during summer (Manoylov and Dominy 2013). Conversely, in the shallow shelf waters of South Carolina, the highest abundances of benthic microalgae communities occurred during summer (Pinckney et al. 2022). Meanwhile, low water levels are one contributing factor that has to be considered as they reduce the densities of benthic microalgae (Masudaa 2016). Although species diversity was high, the low abundance of benthic microalgae across seasons may also have been affected by the ongoing expansion of the Naawan bridge during those months. Deep excavations resulting in increased turbidity may have hindered microalgal growth and caused a decline in species abundance. This highlights that the decline in species abundance of epipelic microalgae results from a combination of factors, including the abundance of specific genera, seasonal variations, and environmental factors.

Community assemblage pattern

The community assemblage pattern of the abundance of benthic microalgae showed significant seasonal variation ($p<0.05$). However, neither the specific stations nor their interaction with seasons significantly affected the microalgae assemblages. This highlights that seasonal factors play a critical role in shaping the abundance patterns of microphytobenthic communities within estuaries.

Environmental variables

Environmental variables play a crucial role in shaping the abundance and distribution of benthic microalgae within estuarine ecosystems. Factors such as temperature, salinity, sediment organic matter content, nutrients, and sediment grain sizes have been found to influence the microorganisms' growth, survival, and community composition (Sommer 2019; Gu et al. 2020). The environmental factors obtained for this study are shown in Table 5.

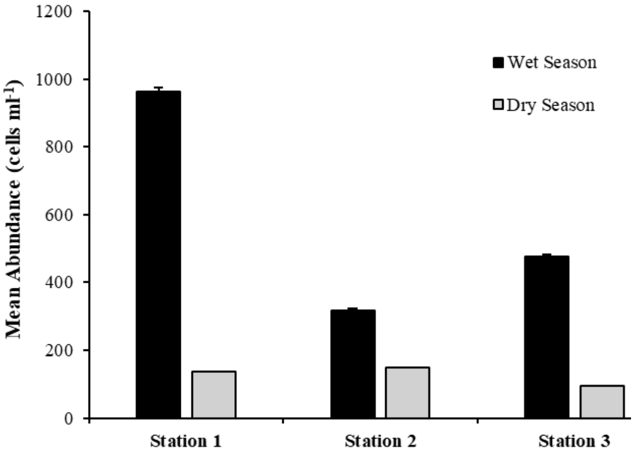

Figure 4. Temporal pattern of the mean abundance of epipelic microalgae across three stations in Talabaan Estuary, Naawan, Misamis Oriental, Philippines

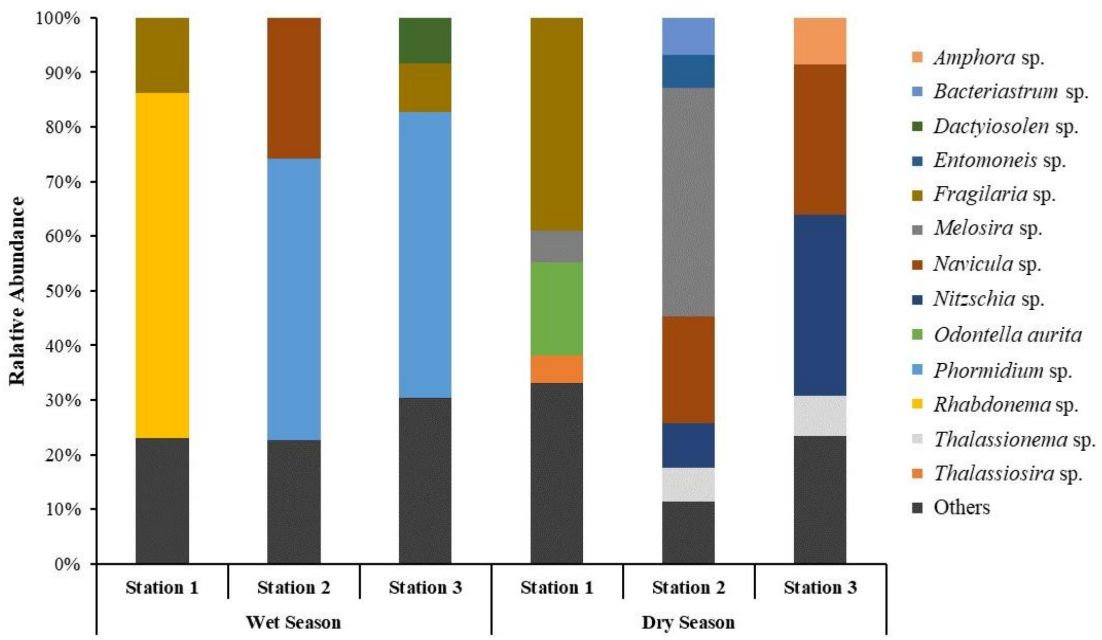

Figure 3. Barplot illustration of the relative abundance of dominant epipelic microalgae with species comprising ≥5% are in colors while other species are clustered and illustrated in black

Table 5. Environmental variables obtained from this study in Talabaan Estuary, Naawan, Misamis Oriental, Philippines

Parameters	**Wet Season**			**Dry Season**		
	Station 1	**Station 2**	**Station 3**	**Station 1**	**Station 2**	**Station 3**
Temperature (°C)	28.7	27.7	29	27.7	27.8	27.1
Salinity (ppt)	16.0	3.3	0.7	4.7	0.3	0
NO_3-N (ppm)	0.146	0.208	0.257	0.036	0.040	0.044
PO_4-P (ppm)	0.044	0.063	0.076	0.050	0.054	0.060
Organic matter (%)	4.902	4.049	16.438	2.558	2.164	1.961

The temperature range observed in this study, ranging from 27 to 29 °C, aligns with the optimal temperature for the growth and reproduction of microalgae (Selviana et al. 2021). Temperature plays an important role in the survival of microalgae because it can affect its composition, abundance, and distribution (Lauritano et al. 2020). For this study, the effect of temperature on the microphytobenthic abundance was found to have significant relationship ($p=0.035$; F value=9.880). Understanding these relationships is crucial for predicting and managing ecosystem responses to environmental changes. Seasonal fluctuations in temperature in estuarine environments can lead to shifts in microalgal community structure, with certain species thriving under specific temperature regimes (Cabrerizo et al. 2021) while others may become less abundant or dormant. However, these fluctuations can also decrease species diversity, as higher temperatures can accelerate competitive exclusion and decrease species richness (Tester et al. 2020). These findings open up exciting avenues for future research, particularly in understanding the dynamics of microalgae communities in response to environmental change.

The salinity levels also shape microalgal assemblages in estuaries, but for this study, salinity levels were not found to affect the structure of microphytobenthic communities. The same pattern was observed in Qua Iboe Estuary, Nigeria, where microalgae assemblages, except for *Closterium* (a genus of soft, green algae), and *Oscillatoria* (a Cyanobacterium), showed significantly negative and positive correlation with salinity during dry and wet seasons, respectively (Essien et al. 2006). Due to the dynamic changes in salinity levels in estuaries, some microalgae species adapted to brackish conditions in the upper reaches of estuaries. In contrast, others are more prevalent in areas with higher salinity levels closer to the ocean. For instance, in station 1, characterized by much higher salinity levels compared to other stations, species such as *Biddulphia* sp., *Bacteriastrum* sp., and *Odontella* sp. are present. Conversely, in the upper reaches where it is dominated by freshwater, the species *Surirella* sp. inhabits.

Nutrients such as nitrate and phosphate, including sediment organic matter, were much higher in the wet than in the dry season. These limiting factors influence the growth of benthic microalgae, especially in tropical estuaries. For instance, Kwon et al. (2013) demonstrated that benthic microalgae, particularly *Nitzschia* sp., have a high capability for nitrate and phosphate uptake, suggesting their potential for phytoremediation. Similarly, phosphate was found to influence the composition and functioning of microbial communities, with different genera dominating in rich, limiting, and stressed conditions (Jha et al. 2022). Meanwhile, sediment organic matter content significantly regulates benthic microalgal abundance and diversity within estuarine sediments. High levels of organic matter can enhance microalgal productivity and biomass accumulation in sediments, increasing the abundance and diversity of benthic microalgae (Fork et al. 2020). However, excessive organic enrichment, often from anthropogenic inputs such as urban or agricultural runoff, can lead to eutrophication and harmful algal blooms (Freeman et al. 2019), posing ecological risks to estuarine ecosystems. Algal blooms in tropical estuaries are often caused by nutrient enrichment, particularly nitrogen and phosphorus inputs from human activities (Teichberg et al. 2009; Sá et al. 2021). These blooms can lead to eutrophication and ecosystem disruption, with some estuaries classified as hypereutrophic (Sá et al. 2021). Factors influencing bloom occurence include nutrient loads, water residence times, and presence of fringing salt marshes (Valiela et al. 1997). Climate events like hurricanes and El Niño can exacerbate blooms by increasing rainfall and nutrient runoff (Phlips et al. 2020). In tropical estuaries, blooms may consists of diatoms like *Leptocylindrus danicus* Cleve 1889 and *Skeletonema costatum* (Greville) Cleve, 1873, or phytoflagellates such as *Clamydomonas* sp. and *Euglena* sp. (Sá et al. 2021). Management of these harmful blooms requires understanding nutrient sources and implementing actions to reduce nitrogen and phosphorus inputs in affected coastal waters (Teichberg et al. 2009).

In conclusion, diatoms dominated the epipelic microalgae community, mainly composed of single-celled species or formed in chains or colonies. Some species are unique for each season, while others exist across time and space. Its abundance appears highest during the wet season, although heavy rainfall and frequent flooding are inherent during these months. In the dry season, mean abundance were observed to be low, although it is expected that reduced terrestrial runoff during these seasons may have enhanced the productivity of microalgae communities. Moreover, the abundance of epipelic microalgae was influenced by seasons, but the stations and the interaction of these variables did not vary significantly. This provides information regarding the species composition and diversity of epipelic microalgae in the Talabaan estuary. Further research could explore the impact of environmental factors and evaluate the effectiveness of benthic microalgae as indicators of ecological change, particularly in local areas.

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