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Assessment of marine macroalgae on selected areas in Lemery, Batangas

Princess Elizabeth Sagala Elias[a], Roen Kaye Gonzales Caraos[a], Regine Perez Bacsa[a], Luigi P. Villalobos[c], Najeen Arabelle M. Rula[a,b,c], Jayvee Ablaña Saco[a,b,c,*]

[a]*College of Arts and Sciences, Batangas State University Pablo Borbon, Rizal Avenue, Batangas City, Batangas 4200, Philippines*

[b]*College of Agriculture and Forestry, Batangas State University - Lobo Campus, Masaguitsit, Lobo, Batangas 4229, Philippines*

[c]*Verde Island Passage Center for Oceanographic Research and Aquatic Life Sciences, Batangas State University - Lobo Campus, Masaguitsit, Lobo, Batangas 4229, Philippines*

ABSTRACT

Seaweeds play important ecological roles in aquatic environments that act as bioindicators of water quality and can be used for bioremediation. The present study assessed the seaweed species in selected sites in Lemery, Batangas that are vulnerable to anthropogenic input and human activities. The line transect-quadrat method was utilized to determine the seaweed spatial distribution and the physicochemical parameters were also measured. A total of four seaweed species were found at Sinisian East, Balanga, and Nonong Casto in Lemery Batangas to which *Ulva intestinalis*, *U. clathrata*, *Acetabularia calyculus*, and *Padina minor* were identified. *U. intestinalis* had the highest contribution in Balanga and Sinisian East (78.34% and 59.64%, respectively) and *U. clathrata* was the most abundant in Nonong Casto (98.62%). *A. calyculus* had the least contribution in Balanga (2.89%). *P. minor* contributed 40.36% only in the Sinisian East. The similarity of profile analysis showed significant clustering of Sinisian East and Balanga due to the similarity of species composition and high abundance of *U. intestinalis* in the two sites. While *P. minor* and *A. calyculus* contributed more than 90% of the dissimilarity between Nonong Casto and the other two sites. Lastly, the physicochemical characteristics, especially the substrate, may possibly contribute to the differences in the species composition and abundance of the three sites.

Keywords: spatial distribution, macroalgae, physicochemical parameters, composition, Lemery

1. Introduction

Marine macroalgae or seaweeds are unicellular or multicellular, macroscopic, eukaryotic, and photo-auxotrophic organisms. They are classified into three groups which are division: Chlorophyta (green algae), Rhodophyta (red algae), and Ochrophyta (brown algae) [1]. They have their own ecological roles in the aquatic environments that supply nutrition and energy to animals, either directly through consumption or indirectly through decaying sections breaking down into tiny particles and being ingested by filter-feeding animals. Seaweeds have multiple uses apart from serving as a food source. They are commonly used in cosmetics, hygiene products, and many others. Seaweeds can also act as a bioindicator of water pollution, as seen in cases of algal blooms [2].

Batangas, one of the provinces in the Philippines, boasts a myriad of marine habitats, some of which remain undiscovered. Lemery, a municipality that serves as a local fishing spot, is among these habitats. There are also some tourists and industrialized areas. Despite being a significant area for marine biodiversity, there is lack of documentation on Lemery's marine life and local people are unaware of the benefits of marine macroalgae. Therefore, it is essential to explore and assess marine macroalgae to expand the understanding of this vital marine ecosystem.

This study determined the composition, contribution, abundance, and diversity of seaweed species in three selected sites. It also assessed the physicochemical characteristics such as temperature, salinity, dissolved oxygen, pH, and substrate of selected sites. It investigated the significant difference in the composition of marine macroalgae across the three sites in Lemery, Batangas.

2. Materials and methods

2.1. Sampling sites

Three selected sites were chosen in Lemery, Batangas namely in Sinisian East (N 13° 54.470' E 120 ° 51.298'), Balanga (N 13° 54.148' E 120° 52.652') and Nonong Casto (N 13° 53.771' E 120° 53.371') (Figure 1). Several resorts have been constructed in Balanga and Nonong Casto, and industries surround the area in Sinisian East, resulting in a significant increase in human activities.

*Corresponding author
Email address: jayvee.saco@g.batstate-u.edu.ph

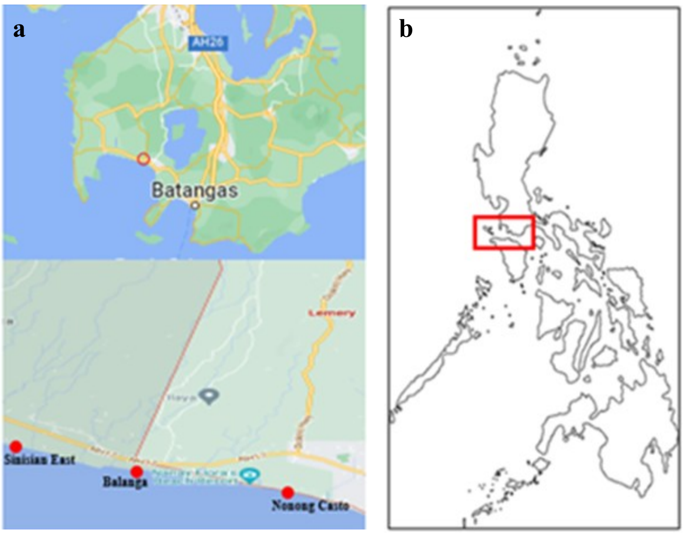

Figure 1. Map of Lemery, Batangas, Philippines showing a) the three selected sites (shaded circle) in Sinisian East, Balanga, and Nonong Casto; b) Philippine map showing the location of the study site (rectangle).

The selected area in Sinisian East is 1.14 km (3,734.31 ft) away from Atlantic Grains Inc. Calaca, an industrialized area. In Balanga, there is a drainage from a creek that flows into the sea; a breakwater, which is 37.30 m (122.39 ft) away from the selected area. As for Nonong Casto, there is a river 1.26 km (4,121.10 ft) away.

2.2. Line transect-quadrat method

The composition, contribution and abundance of marine macroalgae were determined using the line-transect-quadrat method by [3] with modification by [4], in each sampling site in Lemery, Batangas from August to November 2021.

A three-line transect was laid 30 m perpendicularly to the shore with 50 m intervals on each site. A 50 cm^2 quadrat with 10 cm^2 grids was placed every 5 m on the right side of the line transect to prevent bias.

Species composition was determined by identifying all macroalgae present inside each quadrat. The abundance or cover (C, %) of each species was calculated based on following equation; where, *qn* is the total number of small squares with a cover that corresponds to the matrix's index *n*. The coverage was calculated as the sum of each species' cover in a location, and may exceed 100%.

$$C\,(\%) = (qn6 \times 4) + (qn5 \times 3) + (qn4 \times 1.5) + (qn3 \times 0.75) + (qn2 \times 0.375) + (qn1 \times 0.1875) \quad (1)$$

One or more dominant species may exist in the area with 50% or more contribution. It was identified by computing the percent contribution of a species from the total cover of the species over the total summation of the cover of all the species multiplied by 100.

The Shannon's Diversity Index (H') was used to measure diversity and was calculated using the below equation; where, *ni* is the total cover of individual species and *N* is the total cover of all individual species.

$$H' = -\Sigma\left(\left(\frac{ni}{N}\right) ln\, ln \left(\frac{ni}{N}\right)\right) \quad (2)$$

2.3. Physicochemical characterization

The physicochemical data such as temperature (°C), salinity (ppt), pH, and dissolved oxygen (mg/L) were measured using the multi-parameter probe (YSI, Yellow Spring, Ohio, USA) in the three sampling sites.

2.4. Statistical analysis

The significant similarity in the overall cover of marine macroalgae between sites was determined using Similarity Profile (SIMPROF) analysis. Furthermore, to determine which species contributed to the dissimilarity of macroalgae composition among sites, Similarity Percentage (SIMPER) analysis was used. All statistical analyses were carried out using the R software (version 4.1.2, R Core Team, Vienna, Austria).

3. Results and discussion

3.1. Species composition, abundance, contribution, and diversity

Four seaweed species were identified of which three are from the division Chlorophyta: *U. intestinalis* (Figure 2a), a vibrant yellow to green or dark green color and is a hollowed-tubular, wrinkled, and intestine-like seaweed [5] and known to form green tide blooms in a wide range of environments around the world [6]; *U. clathrata* (Figure 2b), a light green, dense mats made up of densely branching soft, delicate, and hair-like hollow filaments that are connected to the substrate or float [7]; *A. calyculus* (Figure 2c), a bright green, goblet-shaped thallus with a long stalk that terminates in a single disk [8,9]; and one from the division Ochrophyta, *P. minor* (Figure 2d), which is a lightly calcified fan-shaped with yellowish-brown to light brown color [7].

The species composition found in Lemery was also observed in the study site of [2] at Verde Island, Batangas City. Likewise in the study site of [10] at Balacbac, Southern Palawan except for the *Acetabularia* sp.

Figure 2. Species composition in the three selected sites in Lemery, Batangas. (a) *U. intestinalis* (b) *U. clathrata* (c) *A. calyculus* (d) *P. minor*.

Table 1 shows that U. *intestinalis* had the highest abundance in the two sampling sites, Balanga and Sinisian East (61.08 % C and 37.13 %C), respectively; lowest in Nonong Casto (0.38%). *U. clathrata* was observed in Nonong Casto and Balanga with an abundance of 27.13 %C and 14.64 %C, respectively.

Table 1. Abundance (%C) of identified marine macroalgal species in the three sampling sites.

Sites	*U. intestinalis*	*U. clathrata*	*P. minor*	*A. calyculus*
Balanga	61.08	14.64	0.00	2.25
Sinisian East	37.13	0.00	25.13	0.00
Nonong Casto	0.38	27.13	0.00	0.00

Species abundance may be influenced by species' morphology, the environment's substandard sewage systems, and runoff from pigpens. Some seaweeds may maximize the limited resources (e.g., light intensity) based on their thallus, and an increase in nutrient content in the water may possibly favor the growth of other seaweed species such as the *Ulva* spp. [11,12].

Table 2 shows that *U. intestinalis* had the highest contribution in Balanga and Sinisian East (78.34% and 59.64%, respectively), and the least contribution in Nonong Casto (1.38%), while, *U. clathrata* had the highest contribution in Nonong Casto (98.62%). *P. minor* had 40.36% contribution in Sinisian East and *A. calyculus* had the least contribution in Balanga (2.89%). Similarly, as observed by [13], *U. clathrata* was one of the highest data contributors in all of their sampling sites in Cagayan. Moreover, exceedingly large contributions of *U. intestinalis* might enhance the ability to form blooms under eutrophic conditions which may form green tides [5].

Table 2. Contribution of each identified species in the three sampling sites.

Sites	Species	Contribution (%)
Balanga	*U. intestinalis* *U. clathrata* *A. calyculus*	78.34 18.77 2.89
Sinisian East	*U. intestinalis* *P. minor*	59.64 40.36
Nonong Casto	*U. intestinalis* *U. clathrata*	1.38 98.62

The Shannon diversity index in Sinisian East was the highest (H'= 0.67446), followed by Balanga (H'= 0.60761) and Nonong Casto which had the least diversity index (H'= 0.07287) (Table 3). Compared to other published studies, the three selected sites have a low marine macroalgae diversity H'= 0.45165). Similarly, a low diversity index was also observed in the study of [14] ranging from H'= 0.42 – 0.80.

Table 3. Shannon diversity index of each species in the three sampling sites.

Sites	Shannon Diversity Index (H')
Balanga	0.60761
Sinisian East	0.67446
Nonong Casto	0.07287

The sandy to muddy substrate may have affected the low diversity of macroalgae in Lemery as observed in Nonong Casto. Whereas, areas with patchy rocky substrate had relatively higher diversity such as in Sinisian East and Balanga compared to Nonong Casto. According to [11], stable substrates such as rocky tend to be sturdier for seaweed anchorage, growth, and survival thus promoting higher diversity. The study of [15] showed that the shallow portion of the intertidal zones characterized by a sandy-rocky substratum favors the growth of *U. clathrata* and other *Ulva* sp.

3.2. Physicochemical characteristics of all sampling sites

Table 4 shows the physicochemical parameters from the three selected sites. The temperature, salinity, and dissolved oxygen measured in all sites were all in the optimum range [11]. The pH values for Balanga (5.50) and Sinisian East (6.02) were below the optimal range and more acidic compared to those of Nonong Casto (7.72). Improper sewage disposal and poor wastewater management are some of the anthropogenic activities that may be responsible for the pollution of the creek. The water in the creek is directly mixed with sewage, which increases the amount of nutrients that go into the sea. This increase in nutrients may be caused by the use of fertilizers and other pollutants, which contribute to an increase in phosphate or nitrate levels [16]. An increase in nitrate concentration leads to a decrease in pH and greater acidity of the seawater [17].

Table 4. Comparison of physicochemical parameters assessed from the three sampling sites.

Parameters	Balanga	Sinisian East	Nonong Casto	Optimal
pH	5.50	6.02	7.72	6.8 - 9.6
DO (%)	96.70	92.80	94.30	80 - 120
DO (mg/L)	7.70	7.11	7.28	6.50 - 8
Salinity (ppt)	32.81	32.85	33.20	30 - 35
Temperature (^{o}C)	28.1	29.50	29.80	20 - 30
Substrate	Sandy - Rocky	Sandy - Rocky	Sandy	-

Both Balanga and Sinisian East had sandy-rocky substrates, while Nonong Casto had sandy substrates. The rockier substrates of Balanga and Sinisian East may have contributed to higher species abundance and diversity compared to the sandy substrates of Nonong Casto.

Differences in marine macrophyte species composition between sampling sites may be explained by variations in habitat factors like substrate and topography, which are known to have an impact on these assemblages [18]. In a study by [19], it was observed that variations in species distribution were due to differences in substrates.

3.3. Difference of macroalgae composition in three selected sites

Figure 3 shows significant clustering of selected sites based on their macroalgae composition and abundance. Sinisian East and Balanga formed a distinct cluster due to the their high abundance of *U. intestinalis*, while Nonong Casto deviated from the cluster having been dominated by species of *U. clathrata.*

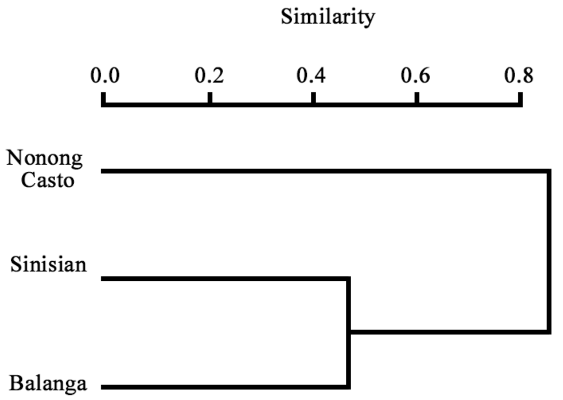

Figure 3. Similarity Profile (SIMPROF) analysis showing the cluster of Sinisian East and Balanga.

The results from the SIMPER analysis (Table 5) showed that *P. minor* and *A. calyculus* contributed more than 75% of the dissimilarity between Nonong Casto and the other two sites. During the sampling period, *P. minor* and *A. calyculus* were not observed in Nonong Casto.

Table 5. Similarity Percentage (SIMPER) analysis of the species contributing to the dissimilarity between sites with a cumulative contribution of ≥ 75.

Sites compared	Species	CC%
Sinisian East vs. Balanga	*U. intestinalis*	0.54
	U. clathrata	0.76
	P. minor	0.95
	A. calyculus	1.00
Sinisian East vs. Nonong Casto		0.41
	U. intestinalis	0.78
	U. clathrate	1.00
Balanga vs. Nonong Casto		0.53
	U. intestinalis	0.94
	U. clathrate	1.00

In the study of [2], during the southwest monsoon, *Padina* sp. also contributed to the dissimilarity of their sites. Similarly, in the study of [20], they observed *Padina* sp. to be one of the contributors to the most dissimilarity of species composition in their sampling period.

4. Conclusions

The sandy to muddy substrates among the selected sites may be the contributing factors to the species composition and their low diversity. Meanwhile, anthropogenic activities such as the sewage system in the area might have affected the pH value of Balanga which was below the optimum range. These factors might have contributed to the similarity and dissimilarity in the macroalgae composition where *U. intestinalis* contributed to the similarity and *A. calyculus* and *P. minor* contributed to the dissimilarity.

Further monitoring or seasonal assessment of the sites should be done with *Ulva* spp. because it has a possibility of producing green tide blooms [2] along with *Padina* spp., being a water pollution bioindicator. Further assessment of the relationship between physicochemical factors and species composition in Lemery, Batangas is recommended.

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