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Diversity and taxonomic assessment of marine benthic macrophytes near mining situated area in Cagdianao, Claver, Surigao Del Norte, Philippines

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Abstract

To obtain a reliable basis for biodiversity conservation and management, basic taxonomic assessment is very important. Marine benthic macrophytes play a very significant role on primary production in marine ecosystems. Taxonomic assessment of marine benthic macrophytes was conducted last January 2016 in Cagdianao, Claver, Surigao Del Norte, Philippines. Data was collected following the line transect methods described by the Aquatic Plant Monitoring and Assessment Methods of Aquatic Ecosystem Restoration Foundation (AERF), with some modifications. Identification of seaweeds and seagrass was done using published taxonomic references and others were from online data base. A total of thirty four (34) species of marine macrophytes belonging to fifteen families were collected and identified at the shallow coastal waters of Cagdianao, Claver, Surigao Del Norte, Philippines. Results shows that station 1 had the most number of individuals suggesting that it might be the most preferable habitat for seagrass and seaweeds followed by station 3, station 4 and study station 2. Economic development activities such as road and building constructions, industrialization, coastal runoffs were all possible threats that could affect the marine ecosystems including the marine benthic macrophyte community which play a crucial role in marine food chain.

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Introduction

Marine macrophytes includes all the macroalgae, seagrasses, mangroves, and phytoplanktons (Trono, 1998). It comprises of thousands species widely distributed throughout the world's shallow coastal areas (Olafsson, 2016). In the Philippines there are 820 species of macrobenthic algae (Trono, 1999) and 16 seagrass species (Rollon *et al.,* 2001). They are the most important primary producers in marine ecosystems (Trono, 1998; Zawawi *et al.,* 2015). It act as an ecological engineers that alters water velocity, it could provide food, stabilize sediments, enhance biodiversity and produce large amount of organic carbon (Orth *et al.,* 2014). Plant diversity along coastal areas also influences animal community because of the services that they provide (Parker *et al.,* 2001). They serves as a critical habitat for many endangered species such as the green sea turtles and dugongs (*Dugong dugon)*, the most threatened marine mammal (Duarte, 2000). Many animals situated within seagrass meadows are commercially important just like crabs and other crustaceans. Hence, coastal ecosystems were important in maintaining marine biodiversity and production of food for human consumption. However, seagrasses and benthic macroalgae were threatened directly by the ever increasing anthropogenic influences. Extreme climatological events have also been identified as one of the major cause of seagrass and macroalgae losses in temperate and tropical regions (Orth *et al.,* 2014). Another environmental challenge for the world's ocean was the introduction of nonnative marine species (Carlton, 1989; Orth *et al.,* 2014). These threatens seagrass and its associates making them vulnerable for extinction.

Biodiversity studies on Philippine seaweeds have started in 1837 (Ganzon-Fortes, 2012). These efforts were significant for it provide an additional basis for conservation of biodiversity. Constant monitoring should be done to minimize severe consequences of marine macrophytes loss. For example, *Dugong dugon* prefers to feed on *Halophila* and *Halodule* species, sudden loss of these species reduces the food availability for endangered species like them (Duarte, 2000). Consequently, loss of *Thalassia hemprichii* have a negative effects in seagrass community structure. It was noted that presence of *Thalassia hemprichii* triggers the development of mixed meadows for other species that were always found in association with it such as *Syringodium isoetifolium* and *Cymodocea rotundata* (Terrados *et al*., 1998; Duarte, 2000). Hence, further research and monitoring was highly recommended for conservation.

Studies about marine benthic macrophyte diversity have been limited to areas around Mindanao especially in Cagdianao, Claver, Surigao Del Norte, Philippines. Data collected from the present study would contribute a better knowledge of marine benthic macrophytes in biodiversity along Cagdianao Bay and it would also serve as a basis for possible coastal management in the local community. This study aimed to: (1) identify and compare the marine benthic macrophytes found along four study stations; (2) to determine possible habitat preferences of seagrass and seaweeds in Cagdinao, Claver, Surigao Del Norte, Philippines.

Materials and methods

Study period and locations

This research was conducted last January 2016. Four study stations located at the shallow coastal waters of Cagdianao, Claver, Surigao Del Norte were selected for data collection showed in Fig. 1. Barangay Cagdianao was located inside the mining area of Claver, Surigao Del Norte. Station 1 was located far from the community, its physical appearance was visibly disturbed due to coastal runoffs. Hence silts, sands, and rocks were common. Station 2 station was characterized by rocky, rubble to fine sediment. This station was slightly away from local community. Study station 3 was located 300m away from Station 4 with rubble to fine sediment. Station 4 was located near the community and river opening. Portions were affected by boating activities in station 4. This station were also characterize by sandy substrate and moderate water current since this area receives direct runoff from the upstreams. Generally, Cagdianao bay was characterized by rocky, rubble to fine sediment and some portions were accumulated with silt especially at study station 1 area. Data collection was done using goggles and snorkeling technique. All marine plants gathered in the field were preserved using 10% formaldehyde and transported back to the laboratory. Herbarium were also made for all plants collected for identification purposes.

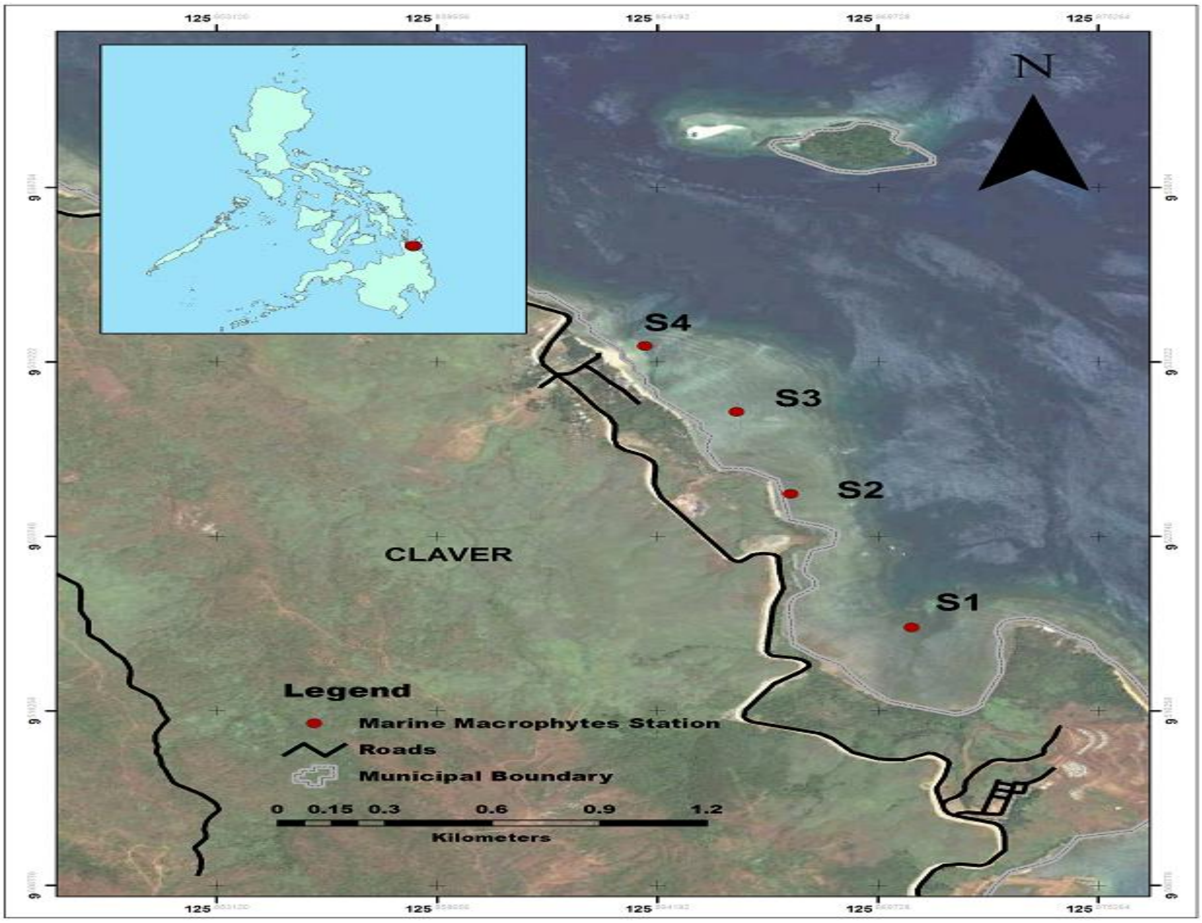

Fig. 1. Map showing the four study stations in Cagdianao, Claver, Surigao Del Norte, Philippines.

Diversity of marine benthic macrophytes

Species list obtained, determined distribution, and estimated the abundance of marine benthic macrophytes at the shallow waters of Cagdianao, Claver, Surigao del Norte, Philippines. Data was collected following the Aquatic Plant Monitoring and Assessment Methods of AERF by Madsen and Wersal (2012) with some modifications. Identification of seaweeds was done using taxonomic references such as Zawawi *et al.* (2015), Silva *et al.* (1987), Verbruggen *et al.* (2005), Ganzon-Fortes (2012), Trono (1988), Hurtado-Ponce *et al.* (1992), others were identified using description from Internet data base.

Statistical analysis

Diversity indices (dominance, Shannon-Weiner index, and evenness) were calculated using Paleontological Statistics Software (PAST).

Results and discussion

Taxonomic assessment of marine benthic macrophytes

Marine benthic macrophytes found in four sampling stations near mining situated area of Cagdianao, Claver, Surigao Del Norte were shown in Table 1 and Table 2. A total of thirty four (34) species of marine macrophytes belonging to fifteen families were collected and identified at the shallow coastal waters of Cagdianao, Claver, Surigao Del Norte, Philippines. For seaweeds, most of the collected species belongs to Division Chlorophyta that includes *Avrainvillea erecta* (Udoteaceae), *Udotea geppii* (Udoteaceae) *Halimeda macroloba* (Halimedaceae), *Halimeda opuntia* (Halimedaceae), *Neomeris* sp. (Halimedaceae), *Bornetella sphaerica* (Dasycladales), *Enteromorpha clathrata* (Ulvaceae), *Ulva intestinalis* (Ulvaceae), *Chaetomorpha linum* (Cladophoraceae), and *Boergesenia forbesii* (Siphonocladaceae).

Table 1. Division, Family and Species of seaweeds collected from shallow coastal areas of Cagdianao, Claver, Surigao Del Norte.

Division	Family	Species
Chlorophyta		
	Udoteaceae	*Avrainvillea erecta* (Berkeley) A. and E.S. Gepp, 1911
		Udotea geppii Yamada, 1930
	Halimedaceae	*Halimeda macroloba* Decaisne, 1841
		Halimeda opuntia (Linneaus) Lamouroux, 1816
		Neomeris sp.
	Dasycladales	*Bornetella sphaerica* (Zanard.) Solms-Laubach, 1892
	Ulvaceae	*Enteromorpha clathrata* (Roth) Greville, 1830
		Ulva intestinalis Linnaeus , 1753
	Cladophoraceae	*Chaetomorpha linum* (O.F.Muller) Kutzing, 1845
	Siphonocladaceae	*Boergesenia forbesii* (Harvey) J. Feldmann
Phaeophyta		
	Dictyotaceae	*Padina minor* Yamada, 1925
		Padina sp.
	Sargassaceae	*Sargassum cristaefolium* C. Agardh, 1820
		Sargassum paniculatum J. G. Agardh, 1824
		Sargassum polycystum C. Agardh, 1824
		Sargassum sp.
		Dictyopteris jamaicencis W. R. Taylor, 1960
Rhodophyta		
	Solieriaceae	*Eucheuma denticulatum* (Burman) Collins and Hervey, 1917
		Kappaphycus alvarezii (Doty) Doty, 1988
	Gracilariaceae	*Gracilaria salicornia* (C. Agardh) Dawson, 1854
		Gracilaria sp. 1
		Gracilaria sp. 2
	Rhodomelaceae	*Laurencia papillosa* (Forsskal) Greville, 1839)
	Corallinaceae	*Amphiroa foliacea* J.V. Lamouroux, 1824
	Lomentariaceae	*Ceratodictyon spongiosum* Zanardini, 1878

Table 2. Phylum, Family and Species of seagrass collected from shallow coastal areas of Cagdianao, Claver, Surigao Del Norte.

Phylum	Family	Species	IUCN status	Current Population Trend
Tracheophyta	Cymodoceaceae	*Cymodocea rotundata*	least concern	(stable)
		Cymodocea serrulata	least concern	(stable)
		Halodule pinifolia	least concern	(decreasing)
		Halodule uninervis	least concern	(stable)
		Syringodium isoetifolium	least concern	(stable)
Tracheophyta	Hydrocharitaceae	*Enhalus acoroides*	least concern	(decreasing)
		Halophila minor	least concern	(unknown)
		Halophila ovalis	least concern	(stable)
		Thalassia hemprichii	least concern	(stable)

In addition, nine out of twenty four species of seaweeds were identified from Division Rhodophyta and it includes *Eucheuma denticulatum* (Solieriaceae), *Kappaphycus alvarezii* (Solieriaceae), *Gracilaria salicornia* (Gracilariaceae), *Gracilaria* sp. 1 (Gracilariaceae), *Gracilaria* sp. 2. (Gracilariaceae), *Laurencia papillosa* (Rhodomelaceae), *Amphiroa foliacea* (Corallinaceae) and *Ceratodictyon spongiosum* (Lomentariaceae). Further, Division Phaeophyta includes *Padina minor* (Dictyotaceae), *Padina* sp. (Dictyotaceae), *Sargassum cristaefolium* (Sargassaceae), *Sargassum paniculatum* (Sargassaceae), *Sargassum polycystum* (Sargassaceae), *Sargassum* sp. (Sargassaceae), *Dictyopteris jamaicencis* (Sargassaceae). On the other hand, nine identified seagrass species that belongs to family Cymodoceaceae and Hydrocharitaceae were recorded.

Table 3. Diversity indices of submergent benthic marine macrophytes in the four study stations in Cagdianao, Surigao Del Norte, Philippines.

Indices	Station 1	Station 2	Station 3	Station 4	Total
Species Richness	19	6	16	7	34
Total Number of individual	128	59	154	144	485
Dominance	0.1322	0.4237	0.1371	0.2393	0.9323
Species Diversity	2.389	1.067	2.207	1.596	7.259
Species Evenness	0.5737	0.4845	0.5682	0.705	2.3314

Most number of seagrass species were from Family Cymodoceaceae which includes *Cymodocea rotundata, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis,* and *Syringodium isoetifolium.* In addition, seagrass species identified from Family Hydrocharitaceae includes *Enhalus acoroides, Halophila minor, Halophila ovalis,* and *Thalassia hemprichii.* Station 1 had the most number of individuals followed by station 3, station 4 and study station 2 (Fig. 2).

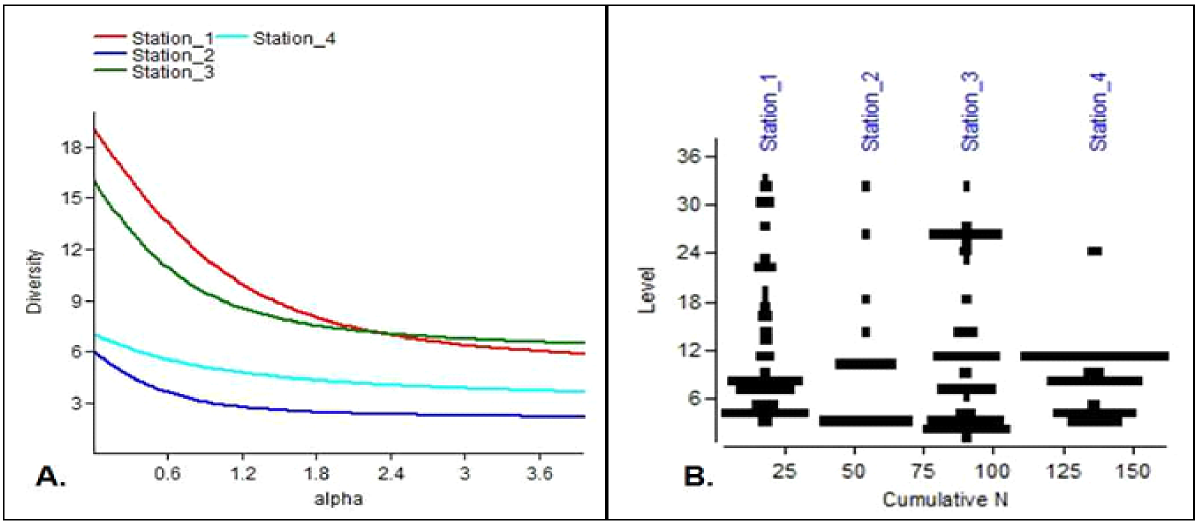

Fig. 2. Diversity profile (A) and spindle diagram (B) of the collected benthic marine macrophytes within four study stations in Cagdianao, Claver, Surigao Del Norte.

Seaweeds and seagrass were autotrophic, photosynthetic plants that are important food source and a habitat for many invertebrates and vertebrates found in coastal area. Typically, seaweeds has a thalloid body that consist of holdfast, stipe, blade, and reproductive structures. These characteristics enables them to inhabit on various types of habitat (Trono, 1998). Seaweeds could form large population on rocky or soft substrata (South, 1993). According to Trono (1999) in the Philippines, Rhodophyta is the most diverse followed by Chlorophyta and last the least diverse was the Phaeophyta but the most common and most abundant. Although seaweeds could potentially sustain life under water they may also threaten other keystone species such as the coral species. It was important to take note the presence of *E. denticulatum, K. alvarezii* and *G. salicornia* which were known to be an invasive species that could cause damage to coral colonies. Additionally, *E. denticulatum* creates a thick covering at the coral reef that reduces the light receives by the plant cells that lives within them (zooxanthellae) and in worst cases stops photosynthesis the driving force behind the growth and productivity of coral reef. Once the photosynthesis stops, the death of the polyps will follow. Moreover, *K. alvarezii* and *G. salicornia* also forms covering that could grow into large colony and infest the coral at the base making coral colony die through shading.

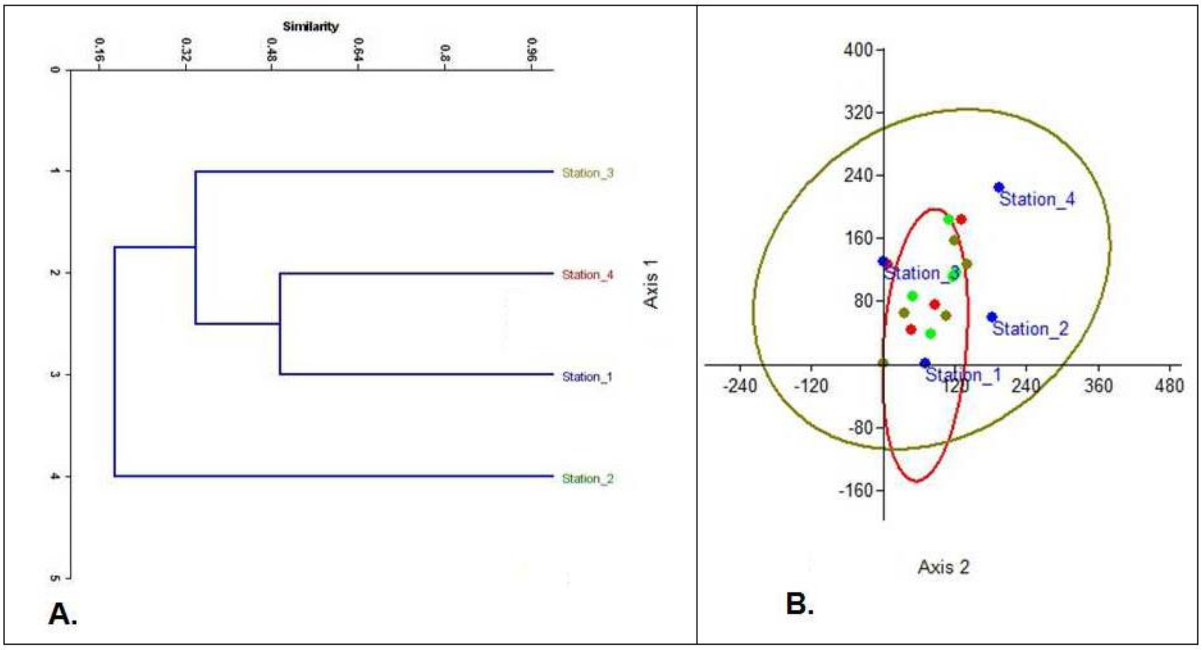

Fig. 3. Multivariate relationship of study stations showing commonality and habitat preferences of marine benthic macrophytes in Cagdianao, Claver, Surigao Del Norte, Philippines.

Furthermore, most of the marine benthic macrophytes collected were not yet evaluated, only the seagrass species have been assessed at the IUCN Red List of Threatened Species. Taken together, current population trend of *H. pinifolia* and *E. acoroides* were said to be decreasing. The most common cause of declining seagrass population has been linked with water quality (Schaffelke *et al.,* 2005*).* Reducing the amount of light alters seagrass to manufacture food. *E. acoroides* has been harvested for food, medicine and fertilizer (Short and Waycott, 2010). Just like *E. acoroides*, overall population trend of *H. pinifolia* were also decreasing. Coastal runoffs, siltation, sedimentation, boating and shipping activities, dredging and coastal developments were all possible reasons of its declining population. Other identified seagrass species (*C. rotundata, C. serrulata, H. uninervis, S. isoetifolium, H. minor, H. ovalis* and *T. hemprichii)* were evaluated as least concern with stable population trend.

Diversity indices and habitat preferences

Diversity and abundance of marine benthic macrophytes varied among stations. Table 3 showed that station 1 had the highest species diversity followed by study station 3, station 4 and station 2. In study station 2, large number of *T. hemprichii* was recorded the reason why it had high dominance value

(0.4) and low species diversity (1.0). Overall species diversity (3.05) was considered high according to the diversity ranges of Odum and Heald (1972). The computed species evenness suggest that most likely each species consist almost the same number of individuals. There was a dominance of three species particularly *C. rotundata, H. pinifolia* and *T. hemprichii* species evenness was low. Figure 3 also showed the trend of distribution and diversity of marine benthic macrophytes and it profess that most of the collected species prefers to thrive at station 1. Among the four stations, study station 1 was the most complex and most unique when it comes to its topography.

In fact, high abundance and species composition in a more complex habitat were caused by more suitable feeding surface, a higher protection against predation and wave action (Stachowicz *et al.,* 2008). This explains distinct groupings of marine benthic macrophytes in station 1 and station 3 compared to other study stations. Distribution and abundance of marine macrophytes variations were evident base on the data collected. These variations could be due to type of substrate, wave condition and activities near the habitat (Zawawi *et al.,* 2015). Increasing input of nutrients may also cause a significant changes on production in tropical marine ecosystems (Schaffelke *et al.,* 2005*).* Accordingly, diversity increases recovery after disturbance and differences in seasonality among species could also contribute to the data collected during the study period (Stachowicz *et al.,* 2008).

Conclusion

Species richness and diversity of marine benthic macrophytes in Cagdianao, Claver, Surigao Del Norte, Philippines has been determined in the present research. Thirty four (34) species of marine macrophytes belonging to fifteen families was identified. Station 1 had the most number of individuals indicating that it might be the most preferable habitat for seagrass and seaweeds followed by station 3, station 4 and study station 2. Economic development activities such as road and building constructions, industrialization, mining influence were all possible threats that could affect the marine ecosystems including the marine benthic macrophyte community which play a crucial role in marine food chain. Monitoring of this valuable resources to determine possible changes and physico-chemical impacts that could alter their natural existence was highly recommended.

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