Abundance and diversity of mangroves in Kinoguitan, Misamis Oriental, Philippines

[1]Annielyn D. Tampus, [2]Anne S. G. Bungcasan, [2]Shaina B. Inte, [2]Patrick R. V. Inotao, [2]Daniel J. H. E. Longcob, [2]Pamela C. K. G. Salise, [2]Ronielyn C. Salig, [3]Astrid L. Sinco

[1] Faculty of Marine Science, College of Science and Mathematics, Mindanao State University, Iligan Institute of Technology, Iligan, Philippines; [2] Marine Biology Studies, Department of Marine Sciences, College of Science and Mathematics, Mindanao State University, Iligan Institute of Technology, Iligan, Philippines; [3] Biology Department, College of Arts and Sciences, Xavier University – Ateneo de Cagayan, Cagayan de Oro, Philippines; Corresponding author: A. D. Tampus, annielyn.tampus@g.msuiit.edu.ph

Abstract. Mangroves are one of the most important vegetation components in the intertidal area. The municipality of Kinoguitan possesses a thick cover of mangrove forest, distributed in 6 coastal barangays. The abundance and diversity of the mangrove forest in Kinoguitan were determined using the Shannon index of diversity. The diameter at breast height, tree height of the mangroves along with environmental conditions were also recorded. A total of eleven (n=11) true mangrove species were surveyed in the entire municipality namely: *Rhizophora mucronata, Sonneratia alba, Avicennia marina, Rhizophora apiculata, Rhizophora stylosa, Excoecaria agallocha*, *Avicennia rumphiana, Lumnitzera littorea*, *Sonneratia caseolaris, Bruguiera* sp., and *Xylocarpus granatum* and one associate mangrove *Nypa fruticans*. The mangroves of Kinoguitan had a Shannon diversity index (H) of 1.63. In terms of diameter at breast height (DBH), the Barangays of Esperanza and Bulisong had most of the old growth mangroves.

Key Words: diameter at breast height, Shannon index of diversity, vegetation.

Introduction. In the tropical coastline, mangroves are one of the prominent features together with seagrass beds (Nagelkerken 2009). Mangroves are salt tolerant evergreen forest ecosystems that are morphologically adapted to tidal ecosystems (Duke 2011). They are present in the tropical and subtropical intertidal regions of the world between approximately 32°N and 38°S latitude. In general, mangrove ecosystems are recognized for the goods and services they provides such as serving as habitats to aquatic species as well as terrestrial organisms (Alongi 2014). Local communities benefit from mangroves as sources of food and subsistence (Satyanarayana et al 2012; Sawairnathan & Halimoon 2017).

The Philippines, a tropical archipelagic nation in Southeast Asia, is regarded as the area with the greatest diversity of mangroves worldwide (Spalding et al 2010). It has approximately 44 true mangroves species, holding at least 68% of the world's approximately 65 mangrove species (Kathiresan & Bingham 2001; Primavera et al 2004). The Philippines is considered one of the top 15 most mangrove-rich countries in the world according to Long & Giri (2011). However, the extent of mangrove areas in the country has been experiencing a rapid decline since the 1900s. This is attributed to overexploitation by coastal dwellers, conversion to agriculture, salt ponds, industry, and settlements. The biggest factor, however, is the mangrove forest conversion to aquaculture ponds (Primavera 2000).

Numerous assessments on mangrove biodiversity in the Philippines have already been done such as in Banaybanay, Davao Oriental and Claver, Surigao del Norte by Pototan et al (2021) and Goloran et al (2020), respectively. Kinoguitan is among the areas of Misamis Oriental with a thick mangrove cover. However, an updated measurement of mangrove cover in Kinoguitan is needed. This assessment will provide updated information that will serve as a basis for future monitoring and policy recommendations to conserve and protect this vital life-support system. This study aimed to determine the abundance and diversity of mangroves in Kinoguitan, Misamis Oriental. Furthermore, the study documented the species composition, relative abundance, frequency, and dominance of mangroves.

Material and Method

Study area. The selected study area is a seaside municipality was in Kinoguitan, Misamis Oriental, presented in Figure 1 along with the plots for field sampling. The municipality makes up 1.36% of Misamis Oriental's total area with a land area of 42.56 km^2, or 16.43 sqm (PhilAtlas 2020). The descriptions of the present status of each sampling station are presented in Table 1.

Table 1

Description of the six sampling sites namely the barangays of Sumalag, Buko, Panabol, Panabol, Poblacion, Bolisong, and Esperanza in terms of soil and other features in Kinoguitan, Misamis Oriental

Site	*Barangay*	*Coordinates*	*Description*
1	Sumalag	8°58'48.89"N 124°47'16.29"E	The site is situated alongside a river. The substrate is muddy covering the depth around 30 cm.
2	Buko	8°59'35.20"N 124°47'53.06"E	The largest mangrove area in Kinoguitan with a mixed substrate of sandy clay and mud. Partly submerged in water even in low tide.
3	Panabol	9°0'2.42"N 124°48'43.28"E	Site is nearby residential houses and chopped mangroves were observed near the shoreline. However, the area has many saplings of *Rhizophora* species. The site has a mixed substrate of sand, near the residential area, and mud.
4	Poblacion	8°58'54.60"N 124°47'21.07"E	Site is surrounded by houses and located near the cemetery area. Freshwater outlets coming from household areas were also observed. The substrate is a mixture of mud and big rocks. Presence of a sea wall was also observed.
5	Bolisong	9°0'13.07"N 124°49'48.14"E	The location of the site is close to houses. *Nypa furticans* also dominated the place. An outlet of freshwater was observed in the area. The substrates were a mixture of sand near the houses, and muddy near the freshwater outlet.
6	Esperanza	9°0'14.22"N 124°49'41.73"E	The site is located in the landward zone not affected by tides. The substrate was composed of sand. Beach resorts were observed within the mangrove area and dead mangrove trees were present in the vicinity due to a recent storm. Mangrove present here were *Avicennia rumphiana*.

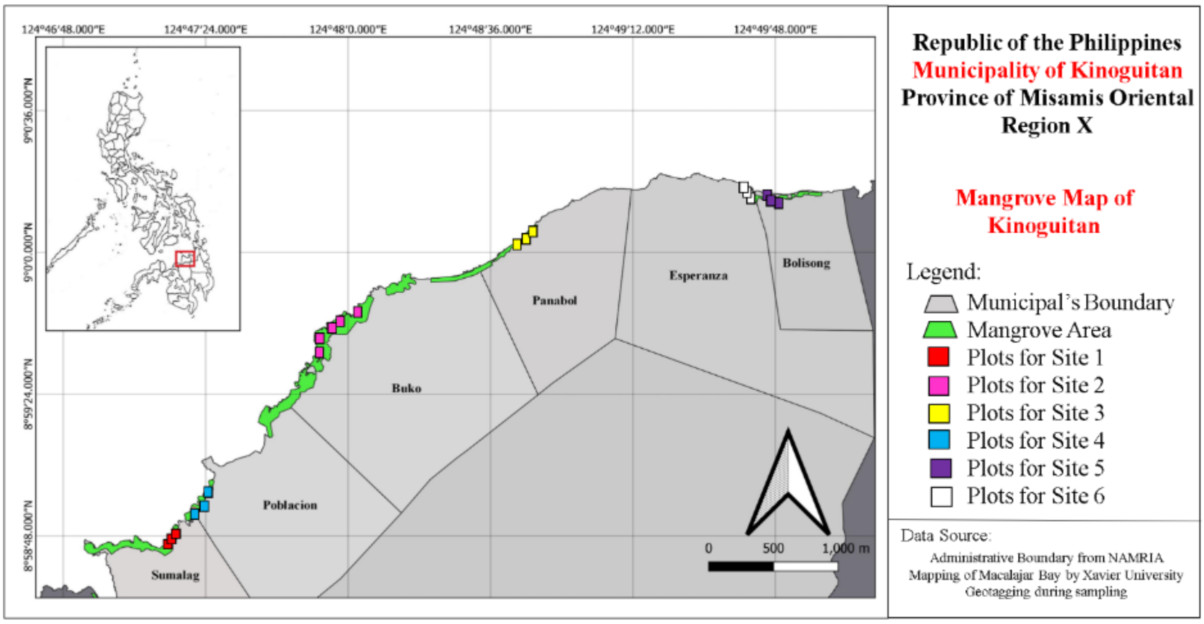

Figure 1. Location map of the sampling stations in Kinoguitan, Misamis Oriental (Source: QGIS version 3.16).

Environmental parameters. Environmental parameters such as water temperature, pH, salinity, and dissolved oxygen (DO) were measured *in situ* during the field sampling. A standard mercury thermometer was used to measure water temperature. A refractometer was used for measuring the salinity (ppt). A pH meter was used for measuring the pH of the water. DO content of the seawater was measured by using a DO meter and the values were recorded as mg L^{-1}.

Field sampling

Establishment of plots. Plots were established in six identified sampling sites in Kinoguitan, Misamis Oriental. Three to five plots with the size of 10x10 m were established at 20-m intervals. 20 m was considered the longest distance that can be accurately surveyed in a dense forest (Dallmeier 1992). The establishment of plots was subjected to accessibility to the sampling site. Hence, purposive random sampling was used in this study.

Mangrove species identification. Mangroves were identified according to the leaf morphology and its phyllotaxy, flowers and fruits. The following references were used to identify the taxonomic classification of mangroves: Calumpong & Meñez (1997), Primavera (2009), and IUCN (2017).

Measurement of abundance and vegetation structure of mangroves. Assessment of mangroves was conducted by the use of the transect-quadrat method (English et al 1997). The height and girth of mangroves that were classified as mature, with height higher than 4 m, were measured and recorded. A 100 m transect line was laid perpendicular to the shore with a 10x10 m quadrat established along the transect line. Furthermore, the trees found inside the quadrat were counted per species and the relative density (RD), relative dominance (RDOM), relative frequency (RF) and importance value (IVI) were calculated with the following formula (Krebs 1989):

Relative density = (Number of species 1/Total number of individuals) x 100

Relative dominance = (Basal area of species 1/Total basal area) x 100

Relative frequency = (Number of plots occupied by species 1/Total number of plots) x 100

Importance value = Relative density + Relative dominance + Relative frequency

Measurement of diameter at breast height (DBH), basal area (BA) and height. The girth was measured by using a tape measure at a standard breast height of 1.3 m and following the standard method presented in Figure 2 for measuring the DBH of mangrove forest with irregular growth (Fourqurean et al 2014). The height of trees (m) was measured using a modified clinometer applying trigonometric techniques (Figure 3). Furthermore, DBH and BA were calculated with the following formula (English et al 1997):

Diameter at breast height (DBH) = Circumference/3.1416

Basal area (BA) = $3.1416(DBH)^2/4$

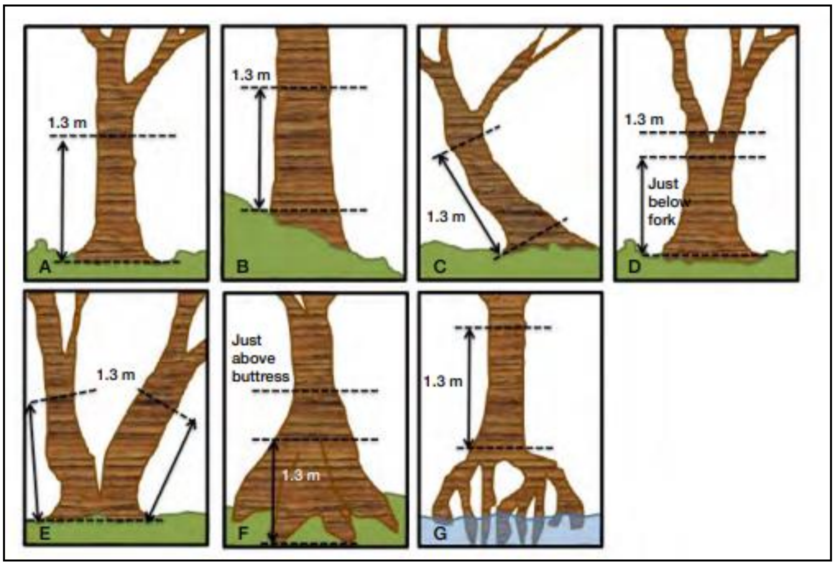

Figure 2. Estimating diameter at breast height for irregular mangrove trees; modified from Pearson et al (2005).

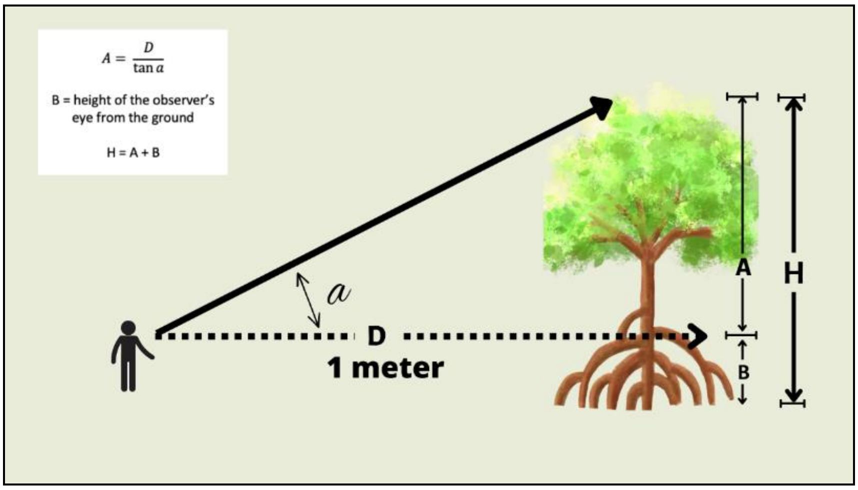

Figure 3. Measurement of height using a modified clinometer (English et al 1997).

Statistical analysis. The Shannon Index of Diversity (H) was determined using the PAST software. Kruskal-Wallis Test was used to determine the differences between the DBH, height (h) and BA of mangroves according to sampling area. Dwass-Steel-Critchlow-Flinger Pairwise Comparison was employed to determine the differences between the sampling sites.

Results and Discussion

Diversity and important value indices. Twelve species of mangroves belonging to 5 orders, 7 families, and 8 genera were found in the six coastal barangays of Kinoguitan, Misamis Oriental (Table 2). *Nypa fruticans* was the only associate mangrove species. The species of true mangrove were *Sonneratia alba*, *Rhizophora mucronata*, *Avicennia marina*, *Rhizophora apiculata*, *Rhizophora stylosa*, *Excoecaria agallocha*, *Avicennia rumphiana, Lumnitzera littorea*, *Sonneratia caseolaris, Bruguiera* sp., and *Xylocarpus granatum*. Barangay Sumalag had four 4 species, Barangay Buko had 7 species, Barangay Panabol had 3 species, Barangay Poblacion had 6 species, Barangay Bolisong had 5 species and Esperanza had 1 species (Table 3).

The H value ranged from 0 to 1.47. Barangay Poblacion has the highest diversity index (H=1.47), followed by Barangay Bolisong (H=1.38) and Buko (H=1.29). Barangay Esperanza had only one species present, *A. rumphiana* (Table 4). The entire municipality of Kinoguitan had an H value of 1.63, higher compared with that of the study conducted in Dumanquillas Bay, Philippines, which was 1.1 (Bitantos et al 2017) and in the study on mangroves in Bahile, Puerto Princesa, Palawan (H=0.99) (Abino et al 2014). Also, the study conducted in Molugan, El Salvador, presented a range of H values from 0.71-1.65 (Taneo 2021).

Table 2

Classification of mangroves in in Kinoguitan, Misamis Oriental

Order	*Family*	*Species*	*Common name*
Myrtales	Lythraceae	*Sonneratia alba*	Pagatpat
		Sonneratia caseolaris	Pagatpat
	Combretaceae	*Lumnitzera littorea*	Culasi
Malpighiales	Rhizophoraceae	*Bruguiera* sp.	Pototan
		Rhizophora mucronata	Bakhaw babae
		Rhizophora apiculata	Bakhaw lalaki
		Rhizophora stylosa	Bakhaw bato
	Euphorbiaceae	*Excoecaria agallocha*	Buta-buta
Lamiales	Acanthaceae	*Avicennia rumphiana*	Miyapi
		Avicennia marina	Miyapi
Sapindales	Meliaceae	*Xylocarpus granatum*	Tabigi
Aracales	Arecaceae	*Nypa fruticans*	Nipa

Table 3

Occurrence of mangroves in 6 sites from Kinoguitan, Misamis Oriental

Area	*Species*										
	Sa	*Sc*	*Ll*	*Br*	*Rm*	*Ra*	*Rs*	*Ea*	*Ar*	*Am*	*Xg*
Sumalag	+	-	-	-	+	+	-	-	-	+	-
Buko	+	-	-	-	+	+	+	+	+	+	-
Panabol	-	-	+	-	-	-	-	-	+	-	-
Poblacion	+	-	-	-	+	+	+	-	-	+	-
Bolisong	-	+	+	+	-	-	-	-	+	-	+
Esperanza	-	-	-	-	-	-	-	-	+	-	-

Note: (+) - present; (-) - absent; Sa - *Sonneratia alba*; Sc - *Sonneratia caseolaris*; Ll - *Lumnitzera littorea*; Br - *Bruguiera* sp.; Rm - *Rhizophora mucronata*; Ra - *Rhizophora apiculata*; Rs - *Rhizophora stylosa*; Ea - *Excoecaria agallocha*; Ar - *Avicennia rumphiana*; Am - *Avicennia marina*; Xg - *Xylocarpus granatum*.

R. mucronata is present in some sampling sites, such as in Barangay Sumalag, Buko and Poblacion. It has the highest total number of individuals and the highest importance value index. The occurrence of this species can be attributed to its ability to withstand high currents, tides and very high salinity (Cañizares & Seronay 2016). *R. mucronata* is a common mangrove in the Philippines with highly viable fruits that last for months (Tamai & Lampa 1988). *Rhizophora* species are often submerged in saline water, and they have adaptations that allow them to survive harsh environment conditions (Baier 1996; Loría-Naranjo at al 2014).

Another genus of mangrove that was observed in Kinoguitan with high numbers of individuals was *Sonneratia,* present in some sampling sites including barangay Sumalag, Buko, Poblacion and Bolisong. The high BA of *Sonneratia* was clearly noticeable. These results show the same trend as in the studies conducted in Sarangani Province (Mullet et al 2014; Natividad et al 2015) and Olango Island Wildlife Sanctuary (Lozano & Bueno 2015), where *S. alba* species have comparatively higher BA compared to other species. *Sonneratia* grow well in all types of soil, such as gravel, very coarse sand, medium sand, fine sand, very fine sand and silt/clay (Mullet et al 2014), showing the resilience of the species.

A. rumphiana individuals were observed in areas located in the inland portion and alongside houses of locals living near the tree. *A. rumphiana* in most sampling sites had a lower number of individuals. However, it has a greater BA compared to other species of mangroves observed, which implies that *A. rumphiana* were more mature than other species. The low density of some of the species may be attributed to the lack of substrate where the species survive and thrive best, in loam and muddy areas (Cudiamat & Rodriguez 2017). Mangrove forests have complex interactions with the surrounding environment (Sherman et al 1998; Gleason et al 2003; Otero et al 2006; Berger et al 2008), where the growth of individual species is affected by both physical and chemical characteristics of soil and seawater (Tomlinson 1986; Smith III 1992; Matthijs et al 1999; Satyanarayana et al 2002).

Table 4

Total number of individuals, basal area, H value and Importance Value Index of mangroves per sampling site

Site	*Species*	*Total no. of individuals*	*Basal area (cm^2) mean ± SD*	*H*	*IVI (%)*
Sumalag	*Sonneratia alba*	2	41.56±20.26	0.77	37.76
	Rhizophora mucronata	61	41.82±25.10		202.07
	Avicennia marina	3	98.50±37.39		44.17
	Rhizophora apiculata	18	63.00±30.73		82.67
Buko	*Sonneratia alba*	5	7591.51±6590.1	1.29	145.48
	Rhizophora mucronata	50	78.61±40.71		137.84
	Avicennia marina	8	67.12±31.82		29.06
	Rhizophora apiculata	3	34.34±6.83		23.19
	Rhizophora stylosa	32	71.25±47.55		96.52
	Excoecaria agallocha	1	107.18		21.21
	Avicennia rumphiana	2	1111.55±1529.17		26.70
Panabol	*Avicennia rumphiana*	9	404.30±355.77	0.33	280.78
	Lumnitzera littorea	1	369.7		52.55
Poblacion	*Sonneratia alba*	9	662.85±751.05	1.47	205.91
	Rhizophora mucronata	9	104.02±58.39		74.42
	Avicennia marina	8	67.00±18.57		66.06
	Rhizophora apiculata	3	64.67±45.44		45.51
	Rhizophora stylosa	2	63.74±60.61		41.42
Bolisong	*Avicennia rumphiana*	6	903.97± 1056.44	1.38	219.01
	Lumnitzera littorea	1	305.9		45.13
	Sonneratia caseolaris	2	231.24±216.56		54.92
	Bruguiera sp.	3	149.45±170.84		62.43
	Xylocarpus granatum	1	803.75		51.82
Esperanza	*Avicennia rumphiana*	6	1197.97±677.94	0	300

Note: H – Shannon diversity index value; IVI - importance value index.

Differences between sampling sites. Table 5 shows the comparison of sampling sites using the Kruskal-Wallis test considering girth at breast height (GBH), h, DBH and BA. Results show that sampling sites vary in terms of GBH, h, DBH, and BA ($p<0.001$). The Dwass-Steel-Critchlow-Flinger Pairwise Comparison further showed that significant differences in terms of the height (Table 6) of mangroves existed between the following sampling sites: Bolisong and Buko, Buko and Panabol, Buko and Sumalag, and Poblacion and Sumalag. The highest number of tall trees was found in Buko and Sumalag indicating that there are more mature trees in these stations. Members of the genus *Rhizophora* had the highest number of individuals recorded in the study sites, especially in Buko and Sumalag. These species present the highest numbers of smallest to largest trees.

The differences in DBH, BA and GBH (Table 7) were observed between the following barangay: Bolisong and Buko, Bolisong and Sumalag, Buko and Panabol, Buko and Sumalag, Panabol and Sumalag, Panabol and Poblacion, and Poblacion and Sumalag. The differences were due to variation in the age of mangrove trees present (Machava-Antonio et al 2022). Sumalag and Poblacion had younger trees since it has relatively low values of BA, DBH and GBH. Bolisong and Esperanza had the highest mean BA, which implies that trees present were mature. Significant differences may also be attributed to the environment of the mangroves, like the type of substrate, the presence of freshwater or saltwater inputs, and the presence or absence of residential areas (Baier 1996; Machava-Antonio et al 2022). Mangrove trees presenting higher mean DBH and height were found in sites where it has more freshwater input. Some comparisons are not significantly different in other sites, probably due to the locations being relatively near to each other.

Table 5

Kruskal-Wallis Test for differences among sampling sites according to GBH, h, DBH and BA

Variable	X^2	*p-value*
GBH	62.9	<0.001
h	55.8	<0.001
DBH	62.9	<0.001
BA	62.9	<0.001

Note: GBH - girth at breast height; h - height; DBH - diameter at breast height; BA - basal area.

Table 6

Dwass-Steel-Critchlow-Flinger Pairwise comparison of height (h) when grouped according to sampling site

Pairwise comparison		
1	*2*	*p-value*
Bolisong	Buko	0.01
	Panabol	0.98
	Poblacion	0.36
	Sumalag	0.90
Buko	Panabol	0.03
	Poblacion	0.96
	Sumalag	<0.001
Panabol	Poblacion	0.49
	Sumalag	0.52
Poblacion	Sumalag	0.01

Table 7

Dwass-Steel-Critchlow-Flinger Pairwise comparison of GBH, DBH and BA when grouped according to sampling site

Pairwise comparison		
1	*2*	*p-value*
Bolisong	Buko	0.01
	Panabol	1.00
	Poblacion	0.22
	Sumalag	<0.001
Buko	Panabol	<0.001
	Poblacion	0.57
	Sumalag	<0.001
Panabol	Poblacion	0.01
	Sumalag	<0.001
Poblacion	Sumalag	<0.001

Note: GBH - girth at breast height; h - height; DBH - diameter at breast height; BA - basal area.

Environmental conditions. Four environmental parameters, pH, temperature, salinity and dissolved oxygen (DO) were measured in each station. However, the environmental conditions within Barangay Esperanza were not determined, since it is located in the landward area, which is not exposed to water and tide (Figure 4).

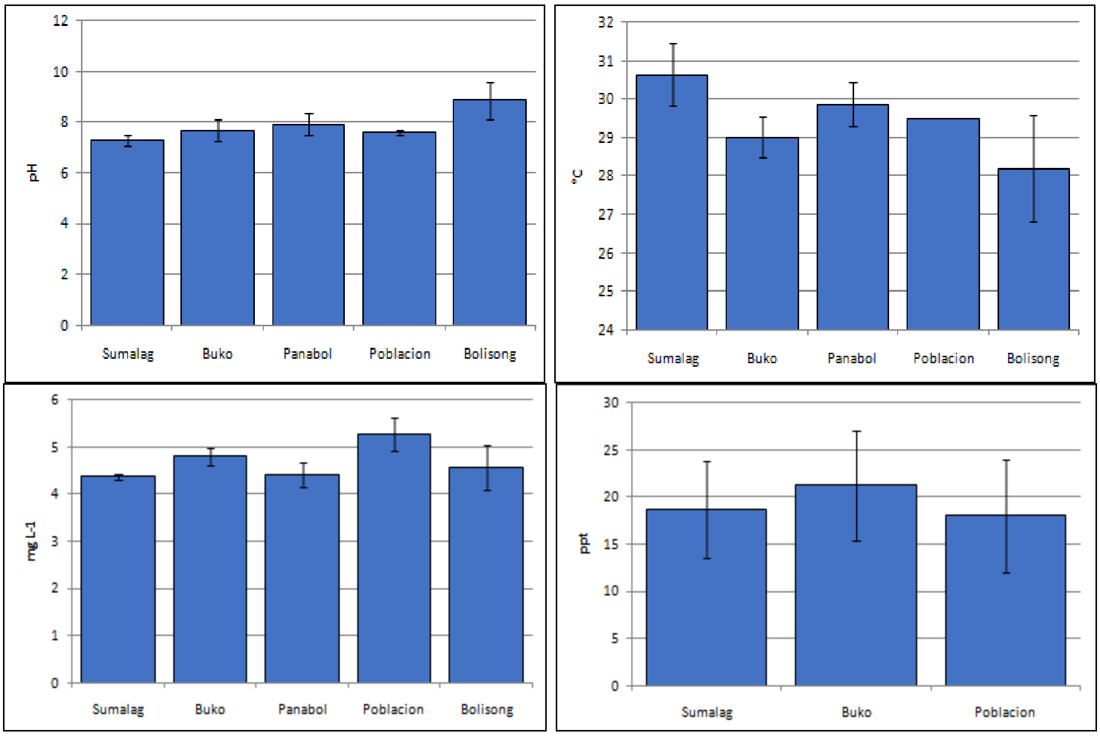

Figure 4. Mean and standard deviation of environmental parameters (pH, temperature, dissolved oxygen and salinity) in the coastal barangays of Kinoguitan, Misamis Oriental.

The average water temperature ranged from 28.8-31.2°C (Figure 4). The water temperature limits the life of mangroves. The temperature data values coincide with the normal temperatures for mangroves, between 20 and 40°C (Supriharyono 2000).

The average recorded salinity was in the range of 0-35 ppt. The differences in water salinity in different sites are influenced by the freshwater inputs. Mangroves are facultative halophytes that can grow and function well up to a salinity of 90 ppt. However, mangrove's best growth is between 5 and 75 ppt (Krauss et al 2008), in which the values recorded in this study are situated. The fluctuations in salt concentration were caused by tides, which drive seawater towards the mangrove area (Parida & Jha 2010).

The pH values ranged from 7.27 to 8.85. The pH values recorded in the different stations ranged from 7 to 7.99, which is a low pH compared with Barangay Bolisong. Mangroves favor areas with pH values ranging from 6.7 to 7.3, slightly acidic to slightly basic, which coincides with the data set obtained by the researchers. The data set values are mostly in the neutral range because it is where most of the nutrients are available to the mangrove plants. Otherwise, when pH conditions are extreme, essential nutrients would be inaccessible to the mangrove plants (Alsumaiti & Shahid 2018).

The mean DO in all stations ranged from 4.36 to 5.26 mg L^{-1}. The values from Barangay Poblacion are above the acceptable minimum value of mangroves set by Philippines DENR, which is 5 mg L^{-1} (DENR-AO No. 2016-08, 2016). The higher values of DO in Barangay Poblacion are due to the more oxygenated water masses from nearby surroundings, like freshwater input (Woodroffe 1992).

Conclusions. The mangrove trees in Kinoguitan, Misamis Oriental were diverse and most trees were mature in age. Most of the mature trees were located in the landward region that is within the reference of the neighborhood or residential houses. The study provided vital information such as geographical locations, freshwater inputs, and types of substrates that would help in identifying the type of mangrove for replanting and rehabilitation actions of the mangal communities with low importance value index.

Conflict of Interest. The authors declare that there is no conflict of interest.

References

Abino A. C., Castillo J. A. A., Lee Y. J., 2014 Species diversity, biomass, and carbon stock assessments of a natural mangrove forest in Palawan, Philippines. Pakistan Journal of Botany 46(6):1955-1962.

Alongi D. M., 2014 Carbon cycling and storage in mangrove forests. Annual Review of Marine Science 6:195-219.

Alsumaiti T. S., Shahid S. A., 2018 A comprehensive analysis of mangrove soil in Eastern Lagoon National Park of Abu Dhabi Emirate. International Journal of Business and Applied Social Science 4(5):39-56.

Baier K., 1996 Factors affecting *Rhizophora mangle* (red mangrove) recruitment in Florida. Nova Southeastern University, Capstone, Florida. Available at: https://nsuworks.nova.edu/cnso_stucap/50

Berger U., Rivera-Monroy V., Doyle T., Dahdouh-Guebas F., Duke N., Fontalvo-Herazo M., Hildenbrandt H., Koedam N., Mehlig U., Piou C., Twilley R., 2008 Advances and limitations of individual-based models to analyze and predict dynamics of mangrove forests: A review. Aquatic Botany 89:260-274.

Bitantos B. L., Abucay M. D., Dacula J. A., Recafort R. D., 2017 Mangrove in the grove: diversity, species composition, and habitat in Pamintayan, Dumanquillas Bay, Philippines. AES Bioflux 9(3):183-192.

Calumpong H. P., Menez E. G., 1997 Field guide to the common mangroves, seagrasses and algae of the Philippines. Bookmark, Makati City, Philippines, 197 p.

Cañizares L. P., Seronay R. A., 2016 Diversity and species composition of mangroves in Barangay Imelda, Dinagat Island, Philippines. AACL Bioflux 9(3):518-526.

Cudiamat M. A., Rodriguez Jr. R. A., 2017 Abundance, structure, and diversity of mangroves in a community-managed forest in Calatagan, Batangas, Verde Island Passage, Philippines. Asia Pacific Journal of Multidisciplinary Research 5(3):27-33.

Dallmeier F., 1992 Long-term monitoring of biological diversity in tropical areas: methods for establishment and inventory of permanent plots. MAB Digest, UNESCO, Paris, 72 p.

Duke N. C., 2011 Mangroves. In: Encyclopedia of modern coral reefs. Springer, Dordrecht, pp. 655-663.

English S., Wilkinson C., Baker V., 1997 Survey manual for tropical marine resources. Chapter 3. Mangrove survey. Australian Institute of Marine Science, Townsville, pp. 119-196.
Fourqurean J., Johnson B., Kauffman J., Kennedy H., Lovelock C., Saintilan N., Alongi D., Cifuentes M., Copertino M., Crooks S., Duarte C., Fortes M., Howard J., Hutahaean A., Kairo J. G., Marba N., Murdiyarso D., Pidgeon E., Ralph P., Serrano O., 2014 Field sampling of vegetative carbon pools in coastal ecosystems. In: Coastal blue carbon: Methods for assessing carbon stocks and emissions factors in mangroves, tidal marshes, and seagrass meadows. Howards J., Hoyt S., Isesnsee K., Telszewski M., Pidgean E. (eds), Conservation International, Intergovernmental Oceanographic Commission of UNESCO, International Union for Conservation of Nature, pp. 67-107.
Gleason S. M., Ewel K. C., Hue N. N., 2003 Soil redox conditions and plant–soil relationships in a Micronesian mangrove forest. Estuarine Coastal and Shelf Science, 56(5-6):1065-1074.
Goloran A. B., Demetillo M. T., Betco G. L., 2020 Mangroves assessment and diversity in coastal area of Barangay Cagdianao, Claver, Surigao Del Norte, Philippines. International Journal of Environmental Sciences & Natural Resources 26(3):556188.
Kathiresan K., Bingham B., 2001 Biology of mangroves and mangrove ecosystems. Advances in Marine Biology 40:81-251.
Krauss K. W., Lovelock C. E., McKee K. L., López-Hoffman L., Ewe S. M., Sousa W. P., 2008 Environmental drivers in mangrove establishment and early development: A Review. Aquatic Botany 89(2):105-127.
Krebs C. J., 1989 Ecological methodology. 1st Edition. Harper & Row, 654 p.
Long J., Giri C., 2011 Mapping the Philippines' mangrove forests using Landsat imagery. Sensors 11(3):2972-2981.
Loría-Naranjo M., Samper-Villarreal J., Cortes J. E., 2015 Structural complexity and species composition of Potrero Grande and Santa Elena mangrove forests in Santa Rosa National Park, North Pacific of Costa Rica. Revista De Biologia Tropical 62(4):33-41.
Lozano E. B., Bueno R. G., 2015 Species composition, diversity and stand structure of mangroves in Olango Island Wildlife Sanctuary, Cebu, Philippines. Cebu Normal University Journal of Higher Education 9:28-38.
Machava-António V., Fernando A., Cravo M., Massingue M., Lima H. L. S., Macamo C., Bandeira S., De Paula J. R., 2022 A comparison of mangrove forest structure and ecosystem services in Maputo Bay (Eastern Africa) and Príncipe Island (Western Africa). Forests 13(9):1466.
Matthijs S., Tack J., van Speybroeck D., Koedam N., 1999 Mangrove species zonation and soil redox state, sulphide concentration and salinity in Gazi Bay (Kenya), a preliminary study. Mangroves and Salt Marshes 3:243-249.
Mullet E. K. C., Lacorte G. H., Hamiladan R. M. A., Arabit C. E. M., Cuales S. O., Lasutan L. G. C., Alagos N. J. S., Kamantu H. G., Protacio K. J. T., Jumawan J. H., 2014 Assessment of mangrove species and its relation to soil substrates in Malapatan, Sarangani Province, Philippines. Journal of Biodiversity and Environmental Sciences 5(4):100-107.
Nagelkerken I., 2009 Ecological connectivity among tropical coastal ecosystems. Springer, Dordrecht, 615 p.
Natividad E. M. C., Hingabay V. S., Lipae H. B., Requieron E. A., Abalunan A. J., Tagaloguin P. M., Flamiano R. S., Jumawan J. H., Jumawan J. C., 2015 Vegetation analysis and community structure of mangroves in Alabel and Maasim, Sarangani Province Philippines. Asian Research Publishing Network (ARPN) – Journal of Agricultural and Biological Sciences 10:97-102.
Otero X. L., Ferreira T. O., Vidal-Torrado P., Macías F., 2006 Spatial variation in pore water geochemistry in a mangrove system (Pai Matos island, Cananeia-Brazil). Applied Geochemistry 21(12):2171-2186.
Parida A. K., Jha B., 2010 Salt tolerance mechanisms in mangroves: a review. Trees 24:199-217.

Pototan B. L., Capin N. C., Delima A. G. D., Novero A. U., 2021 Assessment of mangrove species diversity in Banaybanay, Davao Oriental, Philippines. Biodiversitas 22:144-153.
Primavera J. H., 2000 Development and conservation of the Philippine mangroves: institutional issues. Ecological Economics 35(1):91-106.
Primavera J. H., 2009 Field guide to Philippine mangroves. Zoological Society of London-Philippines, 40 p.
Primavera J. H., Sadaba R. B., Lebata M. J. H. L., Altamirano J. P., 2004 Handbook of mangroves in the Philippines—Panay. SEAFDEC Aquaculture Department, Iloilo, 106 p.
Satyanarayana B., Bhanderi P., Debry M., Maniatis D., Foré F., Badgie D., Jammeh K., Vanwing T., Farcy C., Koedam N., Dahdouh-Guebas F., 2012 A socio-ecological assessment aiming at improved forest resource management and sustainable ecotourism development in the mangroves of Tanbi Wetland National Park, The Gambia, West Africa. AMBIO 41:513-526.
Satyanarayana B., Raman A., Dehairs F., Kalavati C., Chandramohan P., 2002 Mangrove floristic and zonation patterns of Coringa, Kakinada Bay, East Coast of India. Wetlands Ecology and Management 10:25-37.
Sawairnathan M. I., Halimoon N., 2017 Assessment of the local communities' knowledge on mangrove ecology. International Journal of Human Capital in Urban Management 2(2):125-138.
Sherman R. E., Fahey T. J., Howarth R. W., 1998 Soil-plant interactions in a neotropical mangrove forest: iron, phosphorus and sulfur dynamics. Oecologia 115:553-563.
Smith T. J. III, 1992 Tropical mangrove ecosystems: Forest structure (coastal and estuarine series). American Geophysical Union, pp. 106-136.
Spalding M., Kainuma M., Collins L., 2010 World atlas of mangroves. Earthscan, London, 336 p.
Supriharyono, 2000 Pelestarian dan pengelolaan sumber daya alam di wilayah pesisir tropis. Jakarta: Gramedia Pustaka Utama, 108 p.
Tamai S., Iampa P., 1988 Establishment and growth of mangrove seedlings in mangrove forests of southern Thailand. Ecological Research 3(3):227-238.
Taneo L. E., 2021 Inventory of mangrove in Molugan, El Salvador City, Misamis Oriental. International Journal of Advanced Multidisciplinary Studies 1(3):26-47.
Tomlinson B., 1986 The botany of mangroves. Cambridge University Press, New York, 403 p.
Woodroffe C., 1992 Mangrove sediments and geomorphology. In: Tropical mangrove ecosystems. American Geophysical Union, pp. 7-41.
*** DENR-EMB, 2016 Department of Environment and Natural Resources Environmental Management Bureau Administrative Order no. 2016-08. Water Quality Guidelines and General Effluent Standards of 2016. Republic Act no. 9275.
*** IUCN, 2017 The IUCN Red List of threatened species. Available at: https://www.iucnredlist.org
*** PhilAtlas, 2020 Kinoguitan, province of Misamis Oriental. Available at: https://www.philatlas.com/mindanao/r10/misamis-oriental/kinoguitan.html

Received: 19 September 2022. Accepted: 01 December 2022. Published online: 13 April 2023.
Authors:
Annielyn Deocampo Tampus, College of Science and Mathematics, Faculty of Marine Science, Mindanao State University-Iligan Institute of Technology, Andres Bonifacio, Tibanga, 9200 Iligan City, Philippines, e-mail: annielyn.tampus@g.msuiit.edu.ph
Anne Sherlyn Garsuta Bungcasan, Department of Marine Science, Mindanao State University-Iligan Institute of Technology, Andres Bonifacio Avenue, Tibanga, 9200 Iligan City, Philippines, e-mail: annesherlyn.bungcasan@g.msuiit.edu.ph
Shaina Bonghanoy Inte, Department of Marine Science, Mindanao State University-Iligan Institute of Technology, Andres Bonifacio Avenue, Tibanga, 9200 Iligan City, Philippines, e-mail: shaina.inte@g.msuiit.edu.ph
Patrick Raymond Veluz Inotao, Department of Marine Science, Mindanao State University-Iligan Institute of Technology, Andres Bonifacio, Tibanga, 9200 Iligan City, Philippines, e-mail: patrickraymond.inotao@g.msuiit.edu.ph
Daniel Jep Hunneh Estavas Longcob, Department of Marine Science, Mindanao State University-Iligan Institute of Technology, Andres Bonifacio, Tibanga, 9200 Iligan City, Philippines, e-mail: danieljephunneh.longcob@g.msuiit.edu.ph
Pamela Chelsea Kimberlite Gesulga Salise, Department of Marine Science, Mindanao State University-Iligan Institute of Technology, Andres Bonifacio, Tibanga, 9200 Iligan City, Philippines, e-mail: pamela.salise@g.msuiit.edu.ph
Ronielyn Cuaresma Salig, Department of Marine Science, Mindanao State University-Iligan Institute of Technology, Andres Bonifacio, Tibanga, 9200 Iligan City, Philippines, e-mail: ronielyn.salig@g.msuiit.edu.ph
Astrid Lara Sinco, College of Arts and Sciences, Biology Department Chairperson, Xavier University – Ateneo de Cagayan, Corrales Avenue, 9000 Cagayan de Oro; e-mail: asinco@xu.edu.ph

How to cite this article:
Tampus A. D., Bungcasan A. S. G., Inte S. B., Inotao P. R. V., Longcob D. J. H. E., Salise P. C. K. G., Salig R. C., Sinco A. L., 2023 Abundance and diversity of mangroves in Kinoguitan, Misamis Oriental, Philippines. AACL Bioflux 16(2):1025-1036.