MANGROVE ASSESSMENT AND PHYSICOCHEMICAL CHARACTERISTICS OF SOIL AND WATER IN BRGY. BAGUMBAYAN, MUNICIPALITY OF DINAGAT, DINAGAT ISLANDS

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ABSTRACT

Threats to mangrove ecosystems in Dinagat Island have led the researchers to study the species composition, community structure and soil and water quality of a natural mangrove forest in Barangay Bagumbayan, Municipality of Dinagat, Dinagat Island in January 2020. Three 150-meter transect lines were established perpendicular to a 100-meter baseline along the shore. Six (6) species belonging to three (3) families were found: *Rhizophora apiculata, Rhizophora mucronata, Rhizophora stylosa, Bruguiera sexangula, Lumnitzera littorea, and Xylocarpus granatum*. *R. apiculata* and *R. mucronata* consistently had the highest relative densities (27.0-27.9%), relative frequency (60%), relative dominance (26.9-33.0%), and importance values (133.9-120.9), while *X. granatum* had the least values among all species. Species diversity was very low (1.68). Mean phosphorus (P) and potassium (K) content of the soil were moderately high (6 ppm) and sufficient (1097 ppm), respectively, while mean water pH (7.65) and temperature (25.8^{O}C) were within the normal range according to DENR standards. The abundance of Rhizophora species (*R. apiculata, R. mucronata, and R. stylosa*) in the study area indicates favorable conditions for their growth over other mangrove species. Runoff from nearby farms possibly contribute to the high soil phosphorus levels via a river traversing the sampling sites. Sustainable agricultural practices such as the use of organic fertilizers are recommended to minimize the adverse impacts of agriculture on mangrove ecosystems. Conservation efforts may focus on naturally adept species in the area, while future studies may include additional environmental parameters especially in areas affected by pollutants from mining activities.

Keywords: natural mangrove, Bagumbayan, Dinagat, mangrove soil, agricultural runoff

1. INTRODUCTION

At the turn of the century, Philippine mangroves decreased to only 120,000 hectares from half a million, while fish and shrimp ponds increased to 232,000 hectares (Primavera, 2000). Mangrove rehabilitation programs caught on since the 1930s, initially through local groups, which later were funded by the government and international development aid organizations. Given strong funds for mangrove conservation, survival rates were still low and can partly be due to the selection of species not suitable to the plantation sites (Primavera & Esteban, 2008). Mangroves are virtually confined to the tropics growing along tidal mudflats, providing a variety of ecosystem goods and services. Services include coastal protection from tsunamis and habitat for numerous economically important organisms whereas goods include edible products (e.g. fish), fuel wood, and medicines (FAO, 2007).

Soil provides a good source of nutrients for growth and a strong physical structure in the soft sediments for anchorage and stability (Ashman & Puri, 2002). Good mangrove establishment relies on the soil properties (Li et al., 2008; Kamali and Hashim, 2011; Salmo et al., 2013). As stated by Ngole-Jeme et al., (2016) mangrove ecosystem safeguarding requires an understanding of soil morphology to understand the biodiversity and preservation requirements of ecosystems. Knowing soil dynamics is important in formulating future conservation measures (Andrade et al., 2018).

The Province of Dinagat Islands is rich in various natural resources, among which are mangroves ecosystems which provide livelihood and protection to the people in the province. However, the mangroves are threatened by logging, mining, and land conversion

(Conservation International, Department of Environment and Natural Resources [DENR], Haribon 2006; DENR 2014). Dinagat Islands were declared as mineral reservation area through Proclamation 391, s. 1939 by President Manuel L. Quezon. A group called Alyansa Tigil Mina (ATM) in the province reported that about more than 20 mining companies are operating in different parts of the province (Mayuga, 2017). Thus, assessment of the remaining mangrove forests is essential to preserve and protect the remaining mangrove resources of the province. In this study, species were identified, and community structure was determined in a mangrove ecosystem in Bagumbayan, Municipality of Dinagat, Dinagat Island. Environmental parameters such as soil and water quality were measured to understand their contribution to the community structure of the mangrove ecosystem in the area.

2. METHODOLOGY

2.1 Study Site

Dinagat Islands is the third largest Island in the Mindanao biogeographic subregion located in the north of northeastern Mindanao (Villanueva, 2010). Located to the northeast of Surigao Del Norte, it has a total land area of 1,036.34 square kilometers (PhilAtlas, n.d.). This study was conducted in Brgy. Bagumbayan, Municipality of Dinagat, Dinagat Islands, Philippines. It is situated approximately at 9º57'09"N and 125º36'25"E, in the island of Dinagat. As of 2017, its population is at 1,408 (Population Commission, 2017). Natural mangrove ecosystems are found in the area which provide a good location for the study. Soil present in the study area is black in color and identified as muddy clay.

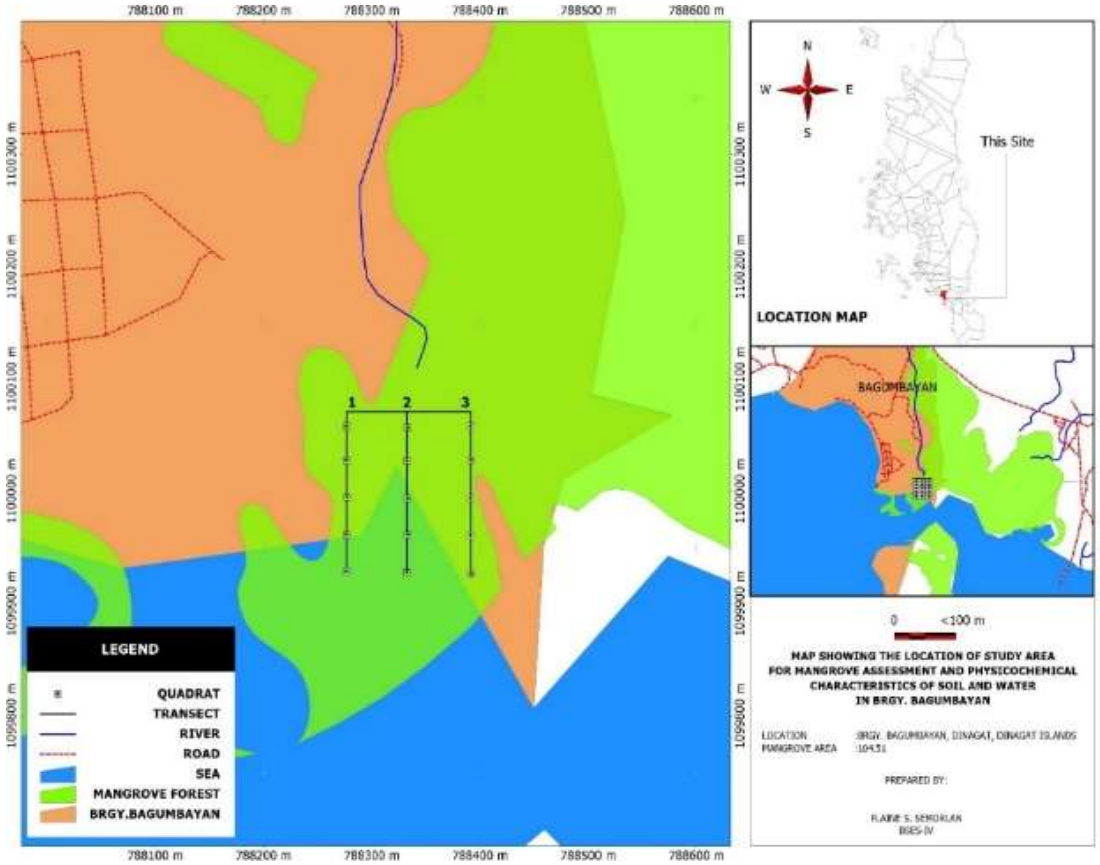

Plate 1. *Location Map of Brgy. Bagumbayan, Municipality of Dinagat, Dinagat Islands*

2.2 Data Gathering Procedure

After courtesy call with the local government units, the study was conducted in January 2020. A 100-meter line was established parallel to the shoreline that serves as a baseline. Three (3) 150-meter transect lines were laid perpendicularly to the shoreline using straw rope (Cañizares & Seronay, 2016). Five 10m x 10m quadrats were plotted within the transect line with an interval of 20 meters per quadrat.

Salinity, pH and temperature were measured three times per plot using a water quality checker (Multi-paramater Water Quality Checker, Model WA2015) and salinity meter *in situ.*

The identification and enumeration of the mangroves was determined *in situ* using the Field Guide Manual to Philippine Mangroves by Primavera (2009). Girth at breast height (GBH) was measured using a tape measure at 1.3 meters above the ground.

One thousand (1000) grams of wet soil were collected in each quadrat at 0 to 30-centimeter depth (Adepetu et al., 1996). The soil samples were air dried and tested for phosphorus (P) and potassium (K) at the Department of Agriculture – Regional Soils Laboratory (CARAGA) in Brgy. Taguibo, Butuan City. To determine the phosphorus content in soil, the Olsen method was used while for potassium content, cold sulfuric acid method was used.

2.3 Data Analysis

The following formula were used:

Diameter at breast height (DBH) = GBH ÷ π (where π = 3.1416)
Basal area = 0.005454 x $(DBH)^2$

Community Structure:

$$\text{Relative density (RDn)} = \frac{\text{no. of individuals of a species}}{\text{total number of individuals}} \times 100$$

$$\text{Relative frequency (RF)} = \frac{\text{frequency of a species}}{\text{sum frequency of all species}} \times 100$$

$$\text{Relative dominance (RDm)} = \frac{\text{total basal area of a species}}{\text{basal area of all species}} \times 100$$

Importance Value (IV) = RDn + RF + RDm

Diversity:

$$\text{Shannon-Wiener Index } (H^1) = \sum_{i=1}^{s} (p_i * \ln p_i)$$

where: p_i = proportion of total sample represented by species *i*;
s = no. of species (species richness)

Table 1.
Shannon-Weiner Categories

Relative Values	H' Values
Very High	>3.50
High	3.00 – 3.49
Moderate	2.50 – 2.99
Low	2.00 – 2.49
Very Low	<1.99

3. RESULTS AND DISCUSSION

Species Composition

Out of forty-four (44) true mangrove species known to be present in the Philippines (Cudiamat & Rodriguez, 2017), six (6) species belonging to three (3) families were found in the study area: *Rhizophora apiculata, Rhizophora mucronata, Rhizophora stylosa, Bruguiera sexangula, Lumnitzera littorea, and Xylocarpus granatum* (Plate 2). This is slightly fewer than the ten (10) true mangrove species identified by Cañizares and Seronay (2016) in Barangay Imelda, Tubajon, Dinagat Islands which is also in the western part of Dinagat Islands. Rhizophoraceae had the highest number of species: *R. apiculata, R. mucronata, R. stylosa, and Bruguiera sexangula*. A total of 244 mangrove trees were recorded, of which *Rhizophora apiculata* had the highest number of individuals (n=68) or about 28% of the total, followed by *Rhizophora mucronata* at 27% (n=66). These species are consistently observed in mid- and seaward zone of the area.

Plate 2.
Mangrove Species found in Brgy. Bagumbayan, Municipality of Dinagat, Dinagat Islands.
A. *Rhizophora apiculata*
B. *Rhizophora mucronata*
C. *Rhizophora stylosa*
D. *Bruguiera sexangula*
E. *Lumnitzera littorea*
F. *Xylocarpus granatum*

Community Structure

R. apiculata had the highest relative density value of 27.9%, closely followed by *R. mucronata* (27.0%) while *X. granatum* has the lowest value of 7.8%. In terms of relative frequency, half of the species had a relative frequency of 60% (*R. apiculata, R. mucronata* and *R. stylosa*), followed by *L. littorea* and *B. sexangula* with similar values of 46.7% while *X. granatum* has the lowest relative frequency of 40.0%. *R. apiculata* had the highest relative dominance value (33.0%), followed by *R. mucronata* (26.9%) while *X. granatum* has the lowest relative dominance value (3.9%). Relative dominance is a function of species count and diameter at breast height (DBH). The high species count per unit area of *R. apiculata* and *R. mucronata* averaging 4.5 species count per quadrat could be the reason why these species turned out to have the highest relative dominance among other species in the area. These results conform to the study conducted by Pototan et al. (2017) in the mangrove areas of Davao del Norte specifically in Tagum City showing that *R. mucronata* & *R. apiculata* has the highest relative dominance among other species recorded. Consequently, *R. apiculata* had the highest importance value of 120.9% closely followed by *R.* mucronata with 113.9% while *X. granatum* has the lowest importance value of 51.7% (Table 2). The high density, frequency, and dominance of *R. apiculata* justifies that this species has the highest importance value among other species recorded in the study. Furthermore, it further implies that *R. apiculata* is very suitable and acclimated mangrove species in the area.

Table 2.
Mangrove Species, Conservation Status and Mean Values of Important Value Index in Brgy. Bagumbayan, Municipality of Dinagat, Dinagat Islands.

Family	Species	Local Name	Conservation Status	RDn (%)	RF (%)	RDm (%)	IV
Combretaceae	*Lumnitzera littorea*	Tabau	Least Concern	11.5	46.7	10.8	69.0
Meliaceae	*Xylocarpus granatum*	Tabigi	Least Concern	7.8	40.0	3.9	51.7
Rhizophoraceae	*Bruguiera sexangula*	Pototan	Least Concern	10.7	46.7	13.7	71.0
	Rhizophora apiculata	Bakauan-lalake	Least Concern	27.9	60.0	33.0	120.9
	Rhizophora mucronata	Bakuan-babae	Least Concern	27.0	60.0	26.9	113.9
	Rhizophora stylosa	Bakuan-bato	Least Concern	15.2	60.0	11.7	86.9

The abundance of the Rhizophora species could be attributed to the muddy clay soil, ample amount of nutrients, and less wave action which are very favorable for these species to thrive compared to other species. Moreover, these species are very common mangrove species in the country because their seeds have very high capability to survive. They have one-seeded fruits which start to germinate while still hanging on the tree (Tamai & Lampa, 1988). In this study, *R. mucronata* and *R. apiculata* were present in most of the sampling quadrats, indicating that these species are very productive and can thrive in all tidal zones as they can withstand high currents and tides and very high salinity (Cañizares and Seronay, 2016).

All recorded species belong to Least Concern conservation status according to International Union of Conservation of Nature (IUCN) Red List. The conservation status of plant species is important in planning and monitoring resource management programs particularly as a guide to conservation actions (Oldfield, 2018). Since all species identified in this study are categorized as Least Concern, this simply means that there are still no major threats to these mangrove species.

Diversity Index

Species diversity in the study area is 1.68 which is categorized as having a very low diversity by Shannon-Weiner's diversity index (Table 3).

Table 3.
Species Diversity in Brgy. Bagumbayan, Municipality of Dinagat, Dinagat Islands.

Area	Species Count	Total no. of individuals	Shannon's Diversity Index (H')	Species Evenness
Barangay Bagumbayan, Municipality of Dinagat, Dinagat Island	6	244	1.68 (very low)	0.94

The lack of species variation in the mangrove stand causes the low diversity (Abino et al., 2014). Several studies concluded that the mangrove stands have very low diversity indices due to their unique stand formation compared to other tropical forest ecosystems (Gevaña et al., 2008; Picardal et al., 2011; Cudiamat & Rodriguez, 2017). Similarly, the study of Cañizares & Seronay (2016) in in Barangay Imelda, Tubajon, Dinagat Islands also had a very low species diversity of 1.97. Species evenness is the measure of how evenly the individuals in the community are distributed over the different species, which ranges from 0 to 1 (Heip et al., 1998). It appears in the result that the species recorded are evenly distributed in the area with a high evenness value of 0.94.

Soil Quality

Average soil phosphorus (P) content was moderately high at 6 parts per million (ppm). Particularly in transects 1 and 2, results were moderately high (6 ppm) and very high (8 ppm), respectively, while transect 3 was moderately low at 5 ppm. For potassium content of the soil, all three (3) transects show sufficient amount with values ranging from 731 to 1356 ppm (Table 4).

Table 4.
Soil Chemical Analysis Results.

Content	Transect	Air-Dry Basis (ppm)	Interpretation
Phosphorus (P)	1	6	Moderately High
	2	8	Very High
	3	5	Moderately low
	Mean	*6*	*Moderately High*
Potassium (K)	1	1203	Sufficient
	2	1356	Sufficient
	3	731	Sufficient
	Mean	*1097*	*Sufficient*

Physico-chemical soil conditions and topography are among the environmental and physiological factors essential to the growth and establishment of mangroves (Shahid et al., 2004). The very high phosphorus content in transect 2 can have a significant effect on the growth of mangroves in the area (Reef et al., 2010) and contributes to higher mangrove productivity (Boto et al., 1994), since phosphorus is often limiting factor to plant productivity. A river passing through transect 2 could be the medium carrying fertilizer runoff from nearby agricultural areas, directly depositing phosphorus into the mangrove soils. This was confirmed by farmers in the area who said that they use fertilizers for their crops. For potassium content, all three transects show sufficient amount in soil which gives good indication that the mangroves species in the study area have good productivity. Potassium content in soil also affects the flowering and seed set of the mangrove species (Des et al., 1997). With this, the soil is suitable for the development and growth of mangroves in Barangay Bagumbayan, Municipality of Dinagat, Dinagat Islands.

Water Quality

Water pH in the three transects were slightly basic (7.66 to 7.70). Low salinity values (2.48 to 2.757) were recorded from the salinity meter. For temperature, results ranged from 25 to 27 degree Celsius. The results are also within the water quality standards (DAO 2016-08) issued by the Department of Environment and Natural Resources (DENR) as shown on Table 5.

Table 5.
Water Quality Mean Physicochemical Values.

Parameter	Mean	DAO 2016 -08 (Class SC)	Evaluation
pH	7.65	6.5-8.5	Passed
Salinity (ppt)	2.52	-	-
Temperature (°C)	25.8	25-31	Passed

Salinity, pH and temperature could affect plant growth; however, the results revealed that these are within the normal range and should not be limiting factor for mangrove productivity in the study area. High salt, low temperature, drought and high temperature are common abiotic stress conditions that adversely affect plant growth and production (Mohammad et al., 2008). Temperature serves as an important regulator of the presence or absence of mangroves. Thus, water quality in the study area is suitable for the growth of mangroves.

Conclusion

The abundance of Rhizophora species (*R. apiculata, R. mucronata, and R. stylosa*) in the mangrove community in Barangay Bagumbayan, Municipality of Dinagat, Dinagat Islands indicate favorable conditions for their growth over other mangrove species. Specifically, soil nutrients (phosphorus and potassium) and water quality (pH, salinity, and temperature) are possibly influential in the productivity of the mangrove species present in the study area. As observed, *B. sexangula*, *L. littorea* and *X. granatum*, which can only survive in low salinity areas, were found in the landward zone while the Rhizophoraceae family (*R. apiculata, R. mucronata,* and *R. stylosa*), which can tolerate higher pH, salinity and temperature, were found in the intermediate up to the seaward zone. The contribution of nearby ecosystems, in this case of agricultural areas, to environmental quality of mangrove ecosystems, is evident in this study, as the use of chemical fertilizers carried through runoff by a river traversing the area result in high levels of phosphorus in mangrove soils. Promotion of the use of organic fertilizers among farmers is recommended to minimize this impact. Future conservation efforts may focus on species which naturally thrive in the area through careful study of soil and water parameters, among other factors. Further studies on other nutrients such as nitrogen, or effects of pollutants in areas where mining activities are present, are also recommended.

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