Effect of type of substrate on the mangrove species diversity in Barangay Magsaysay, Dinagat, Dinagat Islands

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Abstract. This study aimed to evaluate the variety of mangrove species in the area under investigation. Additionally, it looked for information on how different substrate types affected the variety of mangrove species. The data collection process used transect sampling. The researcher approached the proper authorities for permission prior to doing the study. Results showed that seven (7) mangrove species were present: *Rhizophora apiculata*, *Avicennia alba*, *Bruguiera gymnorrhiza*, *Rhizophora mucronata*, *Nypa fruticans*, *Sonneratia alba*, and *Heritiera littoralis* which status were all „least concern" according to the IUCN Red List. In the study region, there were four types of substrate: clay, sandy clay loam, clay loam, and sandy clay. These substrate types substantially impacted mangrove species density, relative density, percent frequency, and diversity indices. The mangrove species diversity in the area is very low, which is alarming because people who live in the mangrove area rely on fishing for their food and livelihood. Since all stations received the very low diversity status and mangrove species are "substrate-specific", they grow best in certain substrate types. The researcher recommends that planters consider the type of substrate in planting mangroves. To improve the diversity status of the mangrove species in their area, the locals should cooperate with the authorities.

Key Words: Brgy. Magsaysay, Dinagat, Dinagat Islands, diversity of mangroves, effects of types of substrate, mangrove species

Introduction. Mangroves are essential ecosystems through which they may host a wide range of living species, including fish, crustaceans, arachnids, insects, nesting birds, and other significant macro-organisms. As such, they are also potential sources of crucial biological materials needed by humanity, such as antibacterial agents and microorganisms with genetic material known to be pest-resistant (UNEP 2014; Abantao et al 2015; Wood 2019). Mangrove species also help defend coastlines, provide nutrients for the ecosystem, regulate erosion, and even act as phytoremediators to remove waste materials from saltwater (Primavera 2004). Given that most people, especially those who live along the coast, depend on the oceans for a living, it is imperative to take fast action for mangrove conservation (Lillo et al 2014).

The regrettable reality is that these vital plant species are slowly disappearing, even though these mangrove species significantly benefit humanity's way of life. Due to anthropogenic disturbances, such as the exploitation of aquaculture, mangrove forests in Southeast Asia, including those in the Philippines, are currently in danger of extinction (Dodd & Ong 2008). Even if mangrove reforestation is of great effort, mangrove species are increasingly degrading due to anthropogenic and environmental stresses (Samson & Rollon 2008). In the Philippines, mangrove species are of shallow diversity, even in areas where urbanization is not yet fully established, like those in Claver, Agusan del Sur, Pilar, Siargao Islands, and Imelda, Dinagat Islands (Abino et al 2014; Lillo et al 2019; Padilla et al 2021). The threatening decrease of mangrove species could be due to anthropogenic stresses and the water and soil quality to which mangrove species are exposed (Jumawan et al 2015; Consigna et al 2020).

With this at hand, the researcher determined the substrate type's effect on the mangrove diversity status in Brgy. Magsaysay, Dinagat, Dinagat Islands. The study identified mangrove species through IUCN Red List and pointed out the present situation as least concern, nearly threatened, threatened, and endangered. The mangrove species' species richness, species abundance, species dominance, and diversity status were considered. The study's overarching goal was to show that the type of substrate affects the species diversity of mangroves.

Material and Method

Research environment. The study was conducted in Brgy. Magsaysay, Dinagat, Dinagat Islands' mangrove area. This mangrove area s at the western portion of the community's port (Figure 1). The majority of the people that lived close to the mangrove area were fishermen. Small to medium-sized fishing boats were docked at the pier.

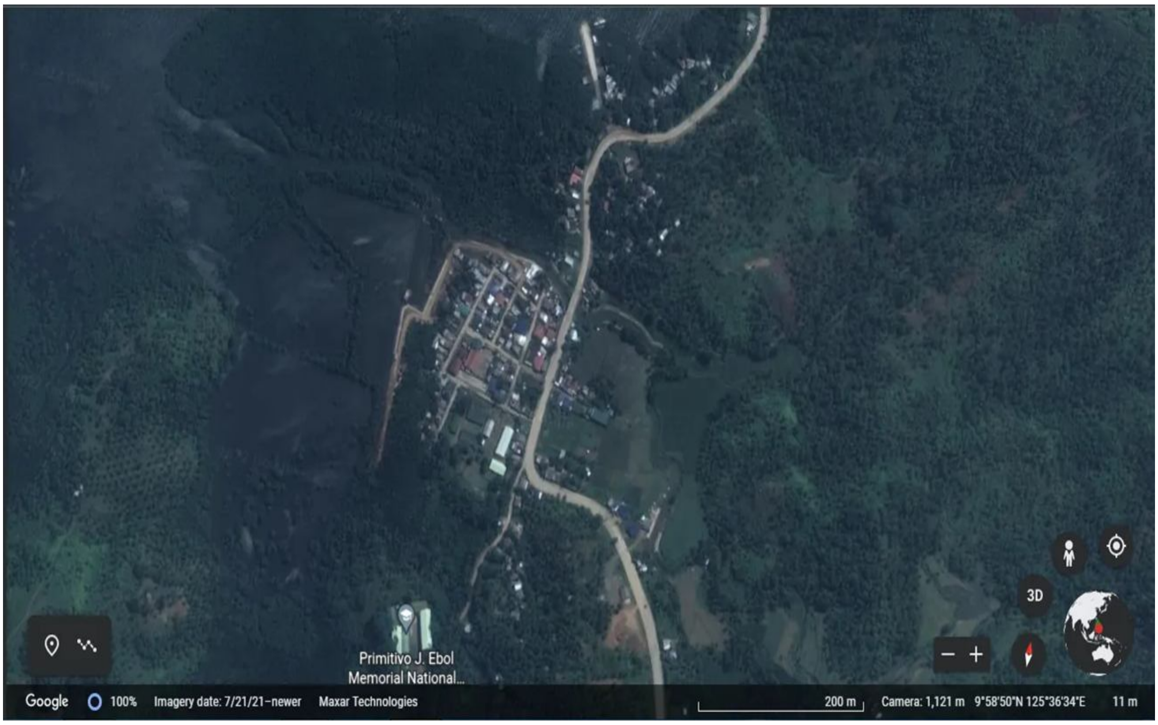


Figure 1. Map of the mangrove area of Brgy. Magsaysay, Dinagat, Dinagat Islands.

Research subjects. The subjects of this study were the mangrove species found in the mangrove area in the locality of Brgy. Magsaysay, Dinagat, Dinagat Islands (Figure 2). These mangrove species are considered true mangroves that can tolerate salinity and can be found only in saline ecosystems (Tomlinson 2016).

Figure 2. Mangrove species.

Study period. The study was conducted from February 2022 until May 2022.

Sampling procedure. Transect sampling was conducted in this study at the study location. The researcher identified four (4) stations or areas. There were six (6) transects in each station, each measuring ten (10) meters by ten (10) meters. The researcher divided the study area into three (3) zones: landward, middle ward, and seaward. Additionally, ten (10) meters separated each region from each zone (Figure 3).

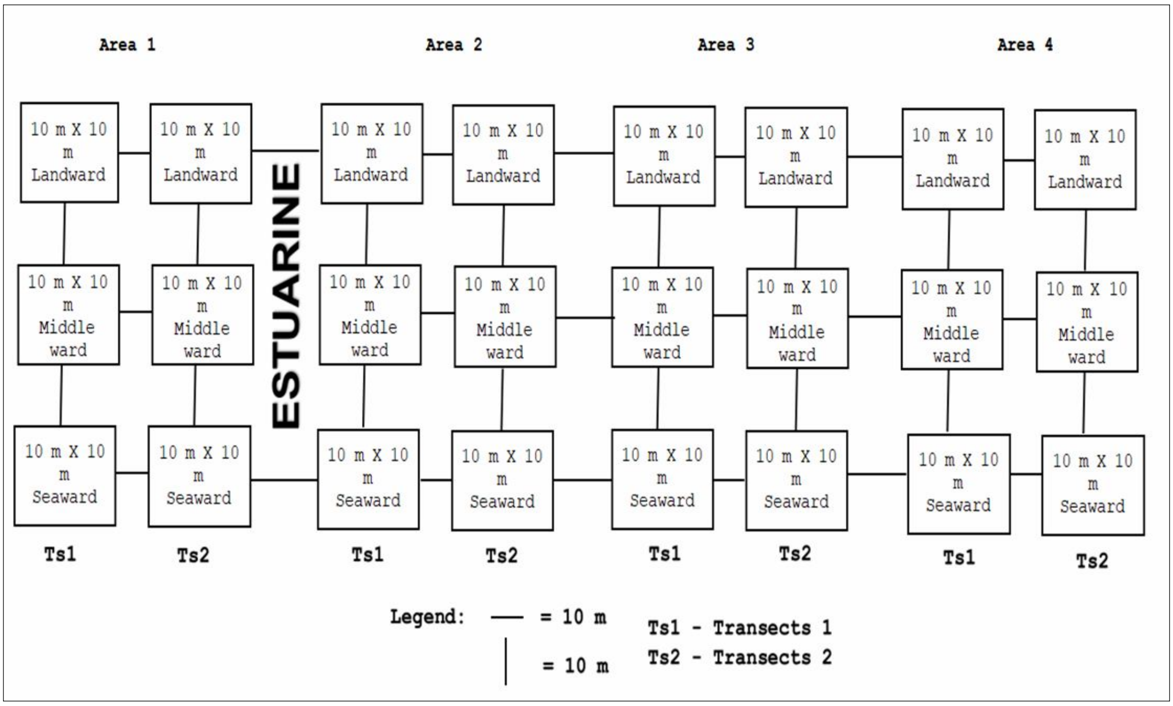


Figure 3. Transect design.

Identification of mangroves. Mangrove species were identified through the International Union for the Conservation of Nature (IUCN) Red List, which contains a list of all types of assessed species from various ecosystems worldwide with statuses of Least Concern, Nearly Threatened, Threatened, and Endangered (IUCN 2022).

Identification of soil substrate. The types of substrate were identified through the Soil Texture Triangle by USDA (Figure 4). The triangle depicts the silt, clay, and sand types of substrate.

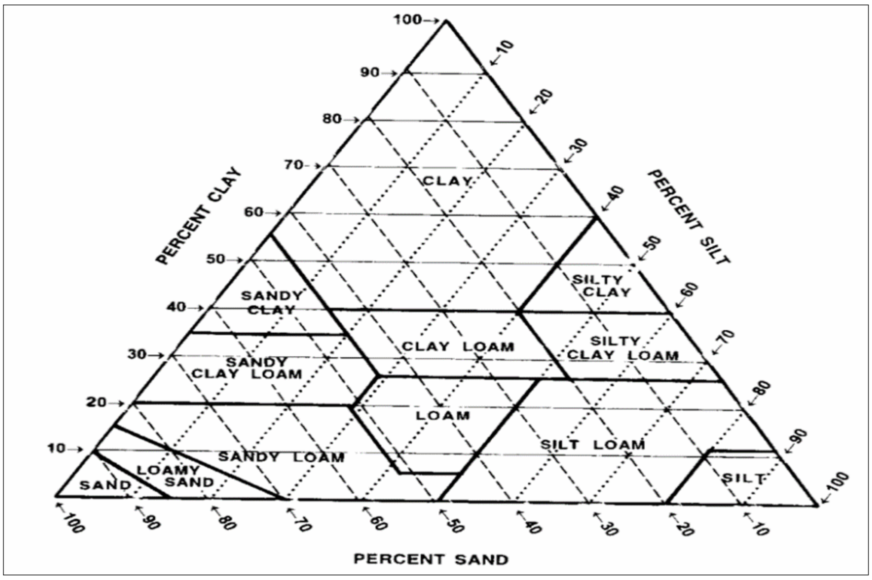


Figure 4. Soil texture triangle (Source: Colorado State University).

Statistical analysis. This study utilized mean, percent frequency, density, relative density, Shannon-Weiner's diversity index, Simpson's diversity index, and Analysis on Variance (ANOVA).

Results. The various substrate types in the study site are listed in Table 1. These substrates were identified using the Soil Texture Triangle, depicted in Figure 4. The substrates were clay, sandy clay loam, clay loam, and clay. According to the data, the substrates in area 1's seaward, middle ward, and landward zones are clay loam, clay, and sandy clay loam, respectively. The middle ward zone substrate in area 2 is clayey, while the seaward and landward zones have a sandy clay substrate. Area 3 is, on the other hand, clayey in the landward zone and clay loam in the middle and seaward zones. Area 4 is also clayey in the middle and landward zones, while sandy clay loam in the seaward zone. The location of the mangrove area was found to be why the study site has distinct types of substrate in each zone and area. The seaward zone, which could be because it faces the oceans directly where tides and waves could carry sands from the coasts and sea bottom, is primarily sandy or has a slight combination of sand, loam, and clay depending on the area. Because it is found in the middle of the three zones and the protection provided by the mangrove species of the seaward and landward zones, the middle ward zone is primarily clayey. Lastly, the landward zone is generally clayey with combinations of sand and loam because it is the frontline of the eroded materials from the houses and rivers, which could bring substances and soils to its substrate.

Table 1

Types of substrate in the study site

Type of substrate	*Area 1*			*Area 2*			*Area 3*			*Area 4*		
	SW	*MW*	*LW*	*SW*	*MW*	*LW*	*SW*	*MW*	*LW*	*SW*	*MW*	*LW*
Clay					√		√	√			√	√
Sandy clay loam			√							√		
Clay loam		√							√			
Sandy clay	√			√		√						

Note: SW = seaward; MW- = middle ward; LW = landward.

Mangrove species in the four substrates. Table 2 presents the scientific names and the statuses of the identified mangrove species in the study area through the IUCN Red List with local names confirmed by Primavera (2009).

Table 2

Mangrove species found in the study site

Species code	*Scientific name*	*Local name*	*Status according to IUCN Red List*	*Clay*	*Sandy clay loam*	*Clay loam*	*Sandy clay*
1	*Rhizophora apiculata*	Bakhaw Lalake	Least concern	+	+	+	+
2	*Avicennia alba*	Bungalon, Apiapi, Miapi	Least concern	+	+	+	+
3	*Bruguiera gymnorrhiza*	Pototan, Busain	Least concern	+	-	+	-
4	*Rhizophora mucronata*	Bakhaw Babae	Least concern	+	+	+	+
5	*Nypa fruticans*	Nipa, Sasa	Least concern	-	-	-	+
6	*Sonneratia alba*	Pagatpat	Least concern	+	-	+	+
7	*Heritiera littoralis*	Dungon	Least concern	-	-	-	+

Species identified were *Avicennia alba*, *Bruguiera gymnorrhiza*, *Heritiera littoralis*, *Nypa fruticans*, *Rhizophora apiculata*, *Rhizophora mucronata*, and *Sonneratia alba*, with a general status of Least Concern as confirmed by the IUCN Red List. Meaning to say these mangrove species can still be found in great numbers in mangrove forests and are not the priority for mangrove conservation. All substrate types contained species 1, 2, and 4, but only the clayey and clay loam substrates contained species 3. Finally, species 6 was discovered in the clayey, clay loam, and sandy clay substrates. Species 5 and 7 were also discovered in the sandy clay substrate. According to the findings, mangrove species are "substrate-specific," implying that they only flourish in suitable environments for their development and survival.

Mangrove species richness. Figure 5 displays the diversity of mangrove species across all substrate types. This shows that sandy clay, which has a total of six species, is the substrate type with the highest species richness, followed by clay and clay loam, which both have a richness of five, and sandy clay loam, which has the lowest species richness of three.

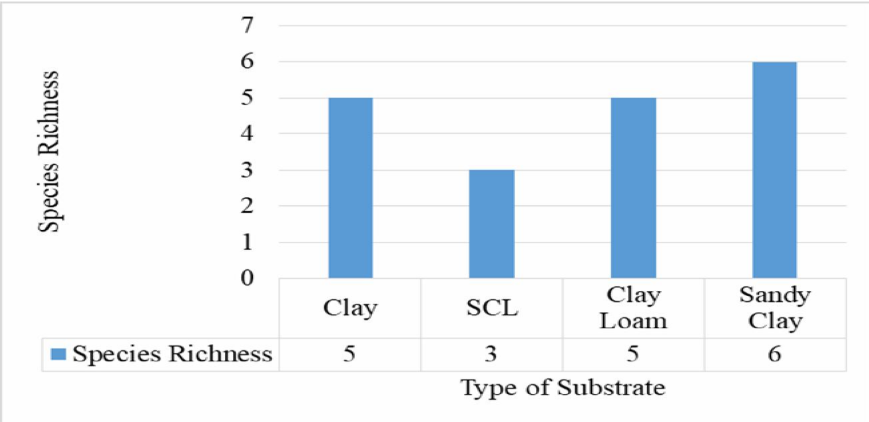


Figure 5. Graph for mangrove species richness per substrate (SCL = sandy clay loam).

Mangrove species abundance (count). The study site's mangrove species count is shown in Figure 6. The substrate clay was found to have the highest species count, followed by substrates sandy clay, clay loam, and sandy clay loam. The richness and abundance of species play a crucial role in determining species diversity. Since they go hand in hand, both should be high enough to guarantee a high species diversity. High diversity is not always a result of high species richness. The same is valid for high species abundance, which does not ensure a high diversity index because both the richness and abundance of a species and its diversity index rise with it.

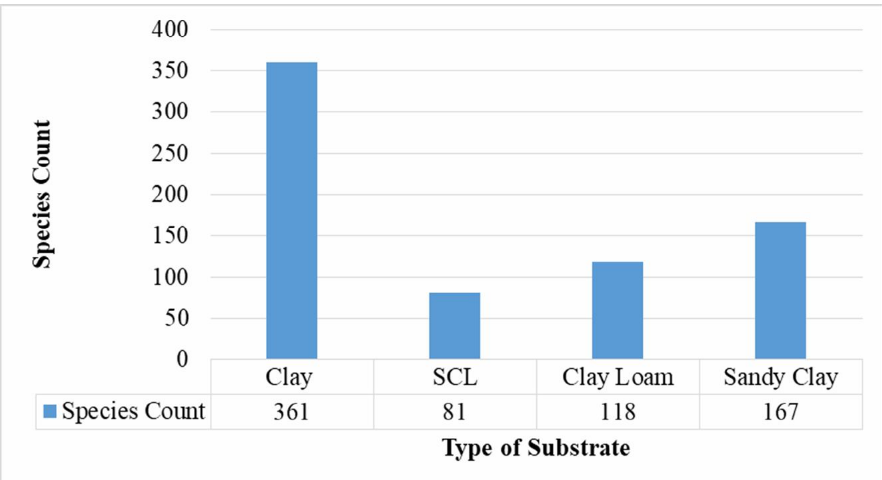
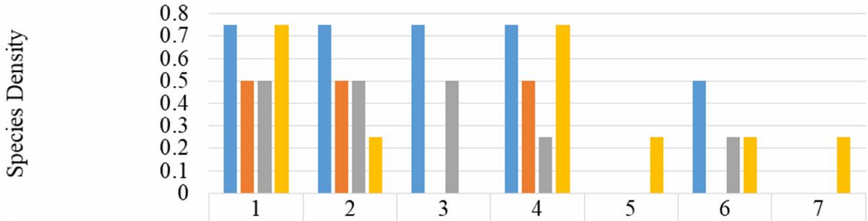


Figure 6. Graph for mangrove species abundance per substrate (SCL = sandy clay loam).

Density. The density of mangrove species per substrate is shown in Figure 7. It shows that species 1, 4, and 6 are most abundant in sandy clay and clayey substrates, while species 2 and 3 are most abundant in substrate clay. However, species 5 and 7 could only thrive on a sandy clay substrate. The data show that the substrate type impacts the species density in the study area. Species density is a measure of species abundance. It was found that a clayey substrate and its combination with sand and loam but not a combination of all, could affect the mangrove species diversity in the area.



	1	2	3	4	5	6	7
Clay	0.75	0.75	0.75	0.75	0	0.5	0
Sandy Clay Loam	0.5	0.5	0	0.5	0	0	0
Clay Loam	0.5	0.5	0.5	0.25	0	0.25	0
Sandy Clay	0.75	0.25	0	0.75	0.25	0.25	0.25

Figure 7. Graph for mangrove species density per substrate.

ANOVA on density. The mangrove species density is significantly different, as seen in Table 3. This indicates that the density of the various mangrove species varies depending on the substrate.

Table 3

Significant differences in mangrove species density

	Sum of sqrs	*df*	*Mean square*	*F*	*p (same)*	*Decision*	*Interpretation*
Between groups	1.27679	6	0.212798	4.469	0.0046	Rejected	Significant
Within groups	1	21	0.047619	Permutation p (n=99999)			
Total	2.27679	27	0.00565				

Relative density. Figure 8 displays the relative density of the mangrove species per substrate. In a clayey substrate, it was discovered that species 5 is relatively the densest, followed by species 1, 3, 2, and 6. Species 1 has the most significant relative density in the sandy clay loam type of substrate, followed by species 2 and 4. On the other hand, species 1, which is comparatively the densest, is followed by species 5, 2, 3, and 4 in a clay loam-type ground. In the sandy clay substrate, species 1 had the highest relative density, followed by species 4, 2, 6, and 7. The relative abundance of each species with the other species in the study site is indicated by the relative density. The graph demonstrates that a clayey substrate has a higher diversity index when compared to other substrate types in the study area, which is in solid agreement with Figure 7. Also demonstrated here is the superiority of clay, sandy clay, and clay loam as substrates for mangrove species.

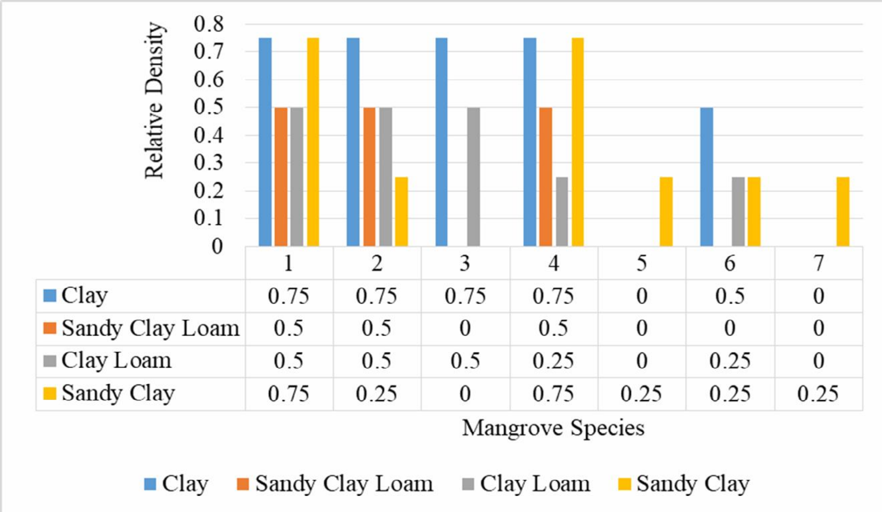


Figure 8. Graph for mangrove species relative density per substrate.

ANOVA on relative density*.* Table 4 demonstrates a considerable variation in the relative density of the mangrove species. This indicates that the relative densities of the various mangrove species vary greatly depending on the substrate.

Table 4

Significant differences in mangrove species relative density

	Sum of sqrs	*df*	*Mean square*	*F*	*p (same)*	*Decision*	*Interpretation*
Between groups	1.27679	6	0.2128	4.469	0.0046	Rejected	Significant
Within groups	1	21	0.04762	Permutation p (n=99999)			
Total	2.27679	27	0.00588				

Percent frequency*.* According to the data (Figure 9), species 1 was most common in three different substrates, including clay loam, sandy clay, and clay loam, whereas species 4 was most common in a clayey substrate. The two substrates, clay and clay loam and clay, and sandy clay, also included species 3 and 6. While species 2 has the highest percent frequency in a sandy clay loam substrate, species five, on the other hand, could only be found in a clay loam substrate. According to the kind of substrate, different mangrove species have different % frequencies, as shown by the graph. Mangrove species are typically found in more significant numbers on particular substrates. For example, species 1 and 2 are most common in sandy clay loam, species 3 and 4 in clayey substrates, species 5 in clay loam, species six was found in both clayey and sandy clay substrates, and species 7 is most common in sandy clay substrates only.

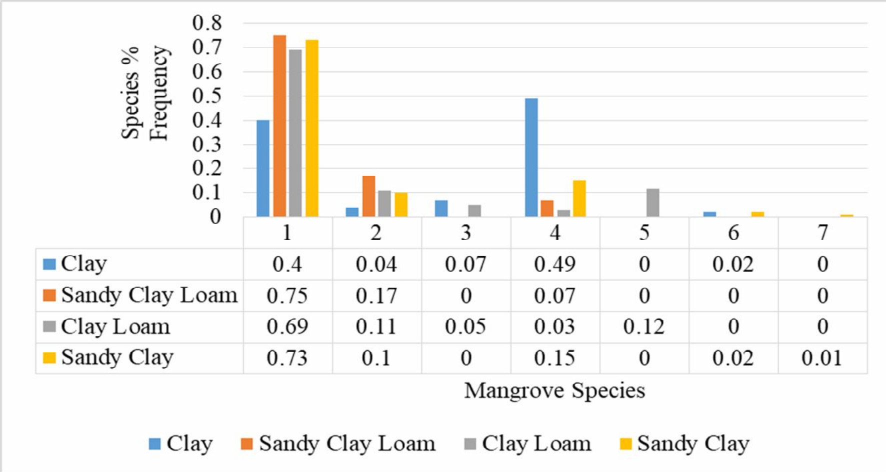


Figure 9. Graph for mangrove species percent frequency per substrate.

ANOVA on percent frequency. The substantial variation in the percent frequency of the mangrove species is reflected in Table 5. It indicates that when examined across all different types of substrate, mangrove species' % frequency dramatically varies.

Table 5

Significant differences in species percent frequency

	Sum of sqrs	*df*	*Mean square*	*F*	*p (same)*	*Decision*	*Interpretation*
Between groups	1.26269	6	0.21045	18.78	1.92E-07	Rejected	Significant
Within groups	0.23535	21	0.01121	Permutation p (n=99999)			
Total	1.49804	27	0.00036				

Mangrove species indices. According to the Shannon-index Weiner's of diversity, the Figure 10 shows that clayey substrate has the most diverse species, followed by clay loam, sandy clay, and sandy clay loam. The most dominant mangrove species are found in sandy clay loam, followed by clay and clay loam substrates. Sandy clay loam has the highest dominance, meaning that the most dominant mangrove species are present in the such substrate. As Shannon-index Weiner's index rises, so do Simpson's diversity index. A clayey substrate has been shown to have the highest Simpson's and Shannon-Weiner's indexes, indicating that it has the most remarkable diversity among the study site's four (4) recognized substrates.

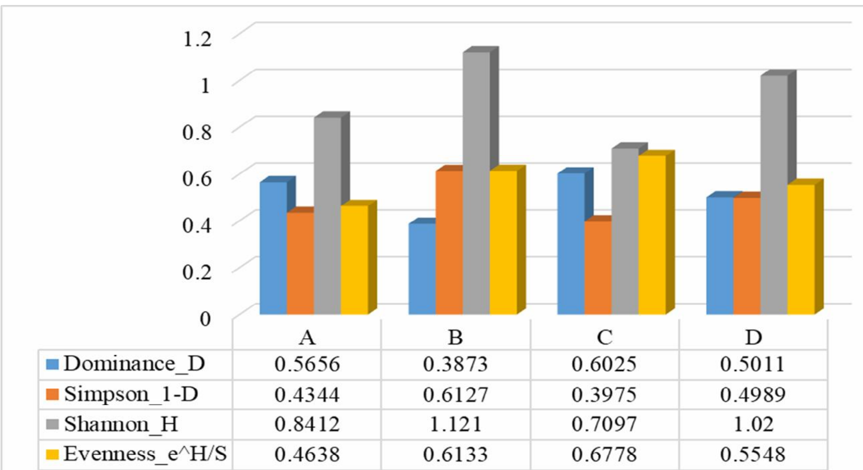


Figure 10. Mangrove species indices per substrate (A = sandy clay; B = clay; C = sandy clay loam; D = clay loam).

ANOVA on mangrove species indices. The substantial variations in mangrove species diversity indicators are seen in Table 6. When examined across all substrates, there is a difference in the diversity of mangrove species with a p-value of < 0.05. It implies that the type of substrate can influence the diversity of mangrove species.

Table 6

Significant difference in mangrove species indices

	Sum of sqrs	*df*	*Mean square*	*F*	*p (same)*	*Decision*	*Interpretation*
Between groups	0.490806	3	0.163602	10.97	0.0009381	Reject	Significant
Within groups	0.179014	12	0.0149178	Permutation p (n=99999)			
Total	0.66982	15	0.00098				

Table 7 displays the Shannon-Weiner diversity index developed by Fernando (1998), with descriptive equivalences of very high, high, moderate, low, and very low. It served as the researcher's starting point when assessing the diversity of the mangrove species in the study area.

Table 7

Shannon-Weiner's descriptive equivalence by Fernando (1998)

H' value	*Descriptive equivalence*
> 3.5	Very high
3.0-3.49	High
2.5-2.99	Moderate
2.0-2.49	Low
< 1.99	Very Low

Source: Cantong et al (2021).

Mangrove species diversity status. Table 8 below shows the diversity status of the mangrove species according to Shannon- Weiner's descriptive equivalence formulated by Fernando (1998). It was discovered that overall, each substrate's mangrove species diversity is rated as Very Low, indicating that authorities and people in the community should be devoted to the preservation of these species.

Table 8

Mangrove species diversity status per substrate

	Clay	*Sandy clay loam*	*Clay loam*	*Sandy clay*
Shannon_H	1.121	0.7097	1.02	0.8412
Descriptive equivalence (Fernando 1998)	Very low	Very low	Very low	Very low

Discussion. According to the IUCN Red List, it was discovered that the local mangrove species are considered to be Least Concern. This indicates that although these mangrove species are still common in most habitats, conservation efforts are not focused on them. However, this is not the situation in Brgy. Magsaysay, Dinagat, and Dinagat Islands because the mangrove species discovered are rated as having a Very Low diversity status in a variety of substrates, which Fernando (1998) determined to be less than 1.9 alarms the local authorities.

The results of this study revealed that the kind of substrate impacts the variety of mangrove species in Brgy. Magsaysay, Dinagat, Dinagat Islands. According to the data, mangrove species differ significantly in terms of richness, species density, relative density, percent frequency, and species indices. The study by Jumawan et al (2015), which claimed that the soil's quality affects the diversity of mangroves in a specific location, supports these findings. Sandy clay is the substrate type with the highest species richness, whereas clay is the substrate type with the highest species abundance (count). However, according to Shannon-Weiner's diversity index, the clayey substrate had the highest diversity index, followed by clay loam, sandy clay, and sandy clay loam. This suggests that mangrove species grow best in a clayey substrate, and they grow well in clay loam and sandy clay substrate, with the sandy clay loam substrate being the least favorable for them to grow.

Present mangrove species include *A. alba*, *B. gymnorrhiza*, *H. littoralis*, *N. fruticans*, *R. apiculata*, *R. mucronata*, and *S. alba*. It has been discovered that these mangrove species are "substrate-specific", meaning they can only survive in places with a particular kind of substrate, as seen in Table 2. *R. apiculata, R. mucronata, and A. alba* were discovered in all substrates, indicating that these three species could survive on substrates made of clay, sandy clay, clay loam, and sandy clay loam. In contrast, *B. gymnorrhiza* was only discovered on clay and clay loam substrates, indicating that these two types of substrates are the only ones where this species may thrive. *N. fruticans* and *H. littoralis* were only discovered on a sandy clay substrate, suggesting that these mangrove species could thrive in an area with a mix of sand and clay soils. Finally, *S. alba* was not found in the sandy clay loam ground, indicating that the clayey, sandy clay and clay loam substrates are the best for this mangrove species. Figures 7, 8, and 9 illustrate how mangroves, which are "substrate-specific", were discovered to be densest, relatively densest, and most frequent in areas where they could grow and prosper.

The ANOVA results revealed considerable variations in the relative density, percent frequency, and species indices reflected in the Shannon-Weiner's and Simpson's indices for mangrove species. This implies that the type of substrate influences the diversity of mangrove species. One of these benefits is the capacity of the mangrove species to thrive in an area where they can grow well, flourish, and proliferate.

Conclusions. In the mangrove area, there were four types of substrate: clay, sandy clay loam, clay loam, and clay. These substrates may have impacted the growth and variety of the reported mangrove species. *Avicennia alba*, *Bruguiera gymnorrhiza*, *Heritiera littoralis*, *Nypa fruticans*, *Rhizophora apiculata*, *Rhizophora mucronata*, and *Sonneratia alba* are the mangrove species present in the study area, which add out to seven (7) in total. The mangrove species in the area were discovered to be "substrate-specific", meaning that they grow or can be found in environments with substrates suitable for such mangrove species. *R. apiculata, R. mucronata,* and *A. alba* are prime examples of this, which were capable of living in clayey, sandy, clay loam, and sandy clay substrates, while *B. gymnorrhiza* was only found in clayey and clay loam substrates. On the other hand, *N. fruticans* and *H. littoralis* were only present in the sandy clay substrate. *S. alba* could be discovered in sandy clay and clay loam substrates. The most diverse substrate was clayey, while a mixture of clay and sand or clay and loam could also produce a greater variety of mangrove species. The kind of substrate has impacted the variety of mangrove species in the area based on significant differences (ANOVA) in species diversity. The diversity of mangrove species in each substrate is typically rated as Very Low.

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Conflict of interest. The author declares that there is no conflict of interest.

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