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Aquatic Macrophytes Composition and Diversity in Selected Sites of Lumbocan River, Butuan City, Agusan del Norte, Philippines

Jeffry M. Saro[a*], Kimberly B. Pascual[b], Deven P. Coquilla[c], Mary Joy P. Araneta[d]

[a]*Research Analyst and Science Teacher, Department of Education, Division of Agusan del Sur, San Rafael, Prosperidad Agusan del Sur 8500, Philippines*

[b]*Teacher I, Department of Education, Division of Butuan City, Barangay Baan Km. 3, Butuan City Agusan del Norte 8600, Philippines*

[c]*Teacher I, Department of Education, Division of Agusan del Sur, Tabontabon, Sibagat Agusan del Sur 8503, Philippines*

[d]*Teacher I, Department of Education, Division of Agusan del Sur, Sta. Irene, Prosperidad Agusan del Sur 8500, Philippines*

[a]*Email: jeffrysaro123@gmail.com*

[b]*Email: kimberly.pascual@deped.gov.ph*

[c]*Email: deven.coquilla@deped.gov.ph*

[d]*Email: maryjoy.araneta001@deped.gov.ph*

Abstract

The aquatic macrophyte species has a great significant impact to the aquatic ecosystem as they plainly provide shelter for young fishes and other aquatic organisms. This study aimed to assess and evaluate the composition and diversity of macrophyte species in selected sites of Lumbocan River, Butuan City, Agusan del Norte, Philippines. The sampling sites were located near the roadway and considered to be swamp area, also it was primarily located along the middle point of Lumbocan River. Nonetheless, the researchers were utilized quadrat sampling as one of the classic tools used in ecology especially determining the diversity of a specific area. A total of 6 species aquatic macrophytes belonging to 6 families and 3 divisions was primarily collected and plainly identified at the study location. The division of Magnoliophyta had three-identified aquatic macrophytes that includes *Pistia stratiotes* (Araceae), *Ipomea pes-caprae* (Convolvulaceae), *Eichhornia crassipes* (Pontederiaceae). While, the division of Pteridophyta had 2 species of aquatic macrophytes, this includes *Ceratopteris thalictroides* (Parkeriaceae) and *Salvinia molesta* (Salviniaceae). Lastly, the division of Tracheophyta had only 1 aquatic macrophyte, the *Euryale ferox* (Nymphaeaceae).

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* Corresponding author.

Overall species diversity of the study sites is also in medium diversity of 1.745 because most likely the macrophyte communities were similar in all transects. Hence, the research study might be used as a baseline for future research, specifically in the context of the ecosystem services, sustainable macrophytes species monitoring and conservation programmes.

Keywords: Macrophyte species; Quadrat sampling; Biodiversity.

1. Introduction

The aquatic ecosystems are extremely rich in biodiversity (Ansari *et.al.,* 2017). Aquatic plants play a variety of ecological roles and contribute significantly to the structure, function, and service provision of aquatic ecosystems. Additionally, an aquatic ecological communities provide an irreplaceable economic and cultural resources to human societies and are presently experiencing more significant loss compared to terrestrial environments, also, dominant aquatic plants have plainly changed from native plants to invasive plants (Xiaolong *and his colleagues* 2020). Biological diversity, describes as Biodiversity as the variations among all organisms. It has an ecological function in the terrestrial marine and other freshwater ecosystem and the other ecological complexities where they are clearly living such as intraspecific diversity and interspecific diversity in the ecosystems (Sufia *and his colleagues* 2019). Aquatic macrophytes has a significant impact and very essential component to the aquatic ecosystem as they provide shelter for young fishes and other aquatic organisms (O'Hare *and his colleagues* 2016). Macrophytes can also be a source of monitoring water quality as, for instance, eutrophication could produce changes in species diversity and its composition. Moreover, the distribution patterns of aquatic macrophytes can be pretentious by many factors such as environmental, topography of the area, physiochemical properties of the water, and climate condition (Brovkin, 2002). Hence, the primary objective is to foretell the spatial and temporal marking in species richness that is indispensable to the protection and contributes significant conservation strategies of the endemic and endangered species in the sites (Ansari *and his colleagues* 2017).

Macrophytes are important elements of aquatic ecosystems that grow in or near water. Their taxonomic composition, species diversity, depth, and density are valuable indicators of environmental health; as such, Macrophytes are used to assess the ecological status of water bodies (Bytyçi *and his colleagues* 2022; De *and his colleagues* 2019). Macrophytes are considered as an important component of the aquatic ecosystem as the habitat and food source for aquatic life (Mitu *et.al.,* 2019). Furthermore, macrophyte vegetation is an important component of various types of aquatic ecosystems. Together with phytoplankton species, these autotrophic organisms are the primary producers that provide the conversion of light energy into organic carbon compounds, thereby contributing to the formation of the trophic structure of aquatic ecosystems. During photosynthesis, macrophytes not only synthesize organic substances, but also release oxygen, which is necessary for the respiration of aquatic organisms and decomposition of organic matter. Aquatic macrophyte vegetation is a food resource for a wide range of herbivores, both invertebrates (snails, crayfish, insect larvae) and vertebrates; in addition, many species of aquatic and wetland macrophyte plants are consumed by humans and used for medical purposes (Lesiv *and his colleagues* 2020).

Several studies have explicitly analyzed environmental factors associated with the richness and species composition of macrophytes, thus, the composition and distribution of aquatic macrophyte species varies with climate condition, substrate type, and hydrology (Garcia, 2018). According to studies, dominant species or traits drive ecosystem functioning, and positive biodiversity–ecosystem function relationships emerge simply because diverse communities are more likely to include high-functioning species, as explained by the selection effect hypothesis. It is thus necessary to assess how each species contributed to overall diversity and productivity, but our understanding has been limited primarily to non-macrophyte ecosystems, with macrophyte ecosystems, particularly in the Philippines, being overlooked (Pasion *and his colleagues* 2021).

In Lumbocan River, a large number of plant species can be collected because it was widely diverse site. The macrophyte surveys was undertaken at selected sample sites. The method employed should be greatly consistent so that the information obtained can be utilized to check the composition and diversity of macrophytes in selected sites. Though number of techniques and methods have been developed for sampling monitoring of aquatic macrophytes in swamps (Agbogidi, 2000). The purpose of this study is to conduct an assessment of macrophyte composition and diversity in selected sites of Lumbocan river, Butuan City, Agusan del Norte, Philippines. Therefore, this study aimed to provides baseline information on the species richness and diversity of aquatic macrophytes living in selected sites of Lumbocan river, Butuan City.

*Corresponding authors: Jeffry M. Saro, Teacher and Educational Research Analyst, Division of Agusan del Sur; Kimberly B. Pascual, Teacher I, Division of Butuan City; Deven P. Coquilla, Teacher I, Division of Agusan del Sur; Mary Joy P. Araneta, Teacher I, Division of Agusan del Sur, Department of Education, CARAGA Region, Philippines

1.1 Objectives of the Study

The main purpose of this study is to assess and evaluate the macrophytes composition and diversity in selected sites of Lumbocan river, Butuan City, Agusan del Norte, Philippines. Specifically, this study also aimed to:

a. Assess and identify the composition of aquatic macrophytes in selected sites of Lumbocan River;
b. Determine and compare the relative frequency and diversity indices of aquatic macrophytes in the area;
c. Determine the distribution and conservation status of aquatic macrophytes living along in the study location.

2. Methodology

This research methodology deals with the study area, description of the sampling sites, collection and identification of aquatic macrophytes, and biodiversity indices analysis.

2.1 Study Area

The study was conducted along the selected sites of Lumbocan River, Butuan City, Agusan del Norte, Philippines. The researchers were explicitly gathered the needed data to assess and determine the macrophyte species composition and diversity indices in the study location.

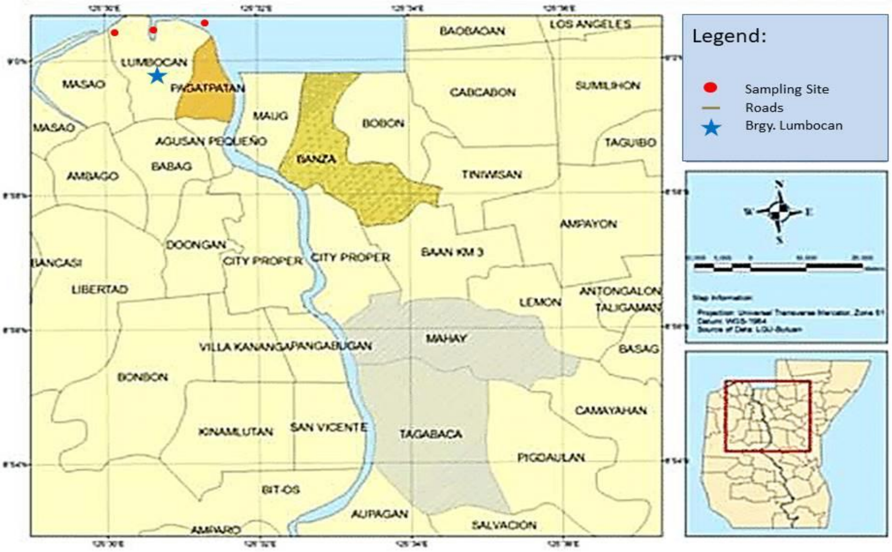

Figure1

2.2 Description of the Sampling Sites

The Lumbocan River were located at Barangay Lumbocan, Butuan City, Agusan del Norte, Philippines. There are three (3) selected sites focused in this study. The first site is located near the roadway and considered to be swamp area. Whereas, the sites 2 and 3 were primarily located along the middle point of Lumbocan River. Also, these sampling sites were situated far away from the community.

2.3 Collection and identification of Aquatic Macrophytes

The researchers were utilized one of the classic tools used in ecology especially determining the diversity of specific area is quadrat sampling. There were three-10m by 10m quadrats established in each study sites of Lumbocan River with an interim of 100 meters. Accordingly, several aquatic macrophytes such as submergent, floating, and floating-leaved were properly collected in selected sampling sites by applying mechanical control utilizing rakes or hand pulling (Helfrich *and his colleagues* 2009) within the Lumbocan River, Butuan City, Agusan del Norte, Philippines. The submerged macrophytes are aquatic plants that are mainly rooted in an area partially cover with water and its vegetative parts were widely emerged in the water surface. An aquatic macrophyte vegetation is a food resource for a wide range of herbivores, both invertebrates (snails, crayfish, insect larvae) and vertebrates; in addition, many species of aquatic and wetland macrophyte plants are consumed by humans and used for medical purposes (Lesiv *and his colleagues* 2020). The collected aquatic macrophyte species was properly identified based on the prominent description from the online platform.

2.4 Biodiversity Indices Analysis

For the quantitative analysis of the study, the researchers were counted the numbers of different aquatic plants species in the quadrat creating the diversity index called the species richness. Also, the researchers were counted the number of aquatic plants per individual species to represent species evenness. Lastly, to calculate and interpret the biodiversity index, the researchers used the Shannon's diversity index and equitability in Excel which was used to determine if the study's location has a low, medium, or high diversity of aquatic macrophytes.

2.5 Species richness

The species richness was probably the first measure used for assessing biodiversity. Counting the number of taxa in the sample under consideration is always the first step. Wherein, often richness or just an estimate of it is the only measure available for large unexplored locations.

2.6 Species evenness

The individuals are not evenly distributed among species. An area containing dozens of species might not be seem particularly diverse if 99.9% of the individuals belong to the same population. With that, evenness is defined as the ratio of observed diversity to maximal possible diversity if all species in a sample were definitely equally abundant.

2.7 Shannon's diversity index

The Shannon diversity index is one of a so-called family of heterogeneity indices. These indices do not particularly take taxa richness into account yet also depend on the relative distribution of individual species. Withal, the logarithm can be taken to any base but taken to these of two gives H a special meaning: bits per species. It is the mean number of binary decisions necessary to determine the exact taxum of an individual species.

3. Results and Discussions

The aquatic Macrophytes comprise a taxonomically diverse group of macroscopic plants including representatives of vascular aquatic plants, bryophytes, as well as green macroalgae and charophytes. From a systematic point of view, aquatic macrophytic vegetation encompasses members of different groups, including green macroalgae (Chlorophyta, e.g., Cladophora spp.), charophytes (Charophyceae, e.g., Chara and Nitella spp.) and higher aquatic plants, the latter being represented by both vascular plants (Tracheophyta) and bryophytes (Lesiv *and his colleagues* 2020). In relation, aquatic macrophytes found along the selected sites of Lumbocan River, Butuan City were shown in Table 1 and Figure 2. A total of six (6) species of aquatic macrophytes belonging to 6 families and 3 divisions were collected and plainly identified at the study location. The division of Magnoliophyta had three-identified aquatic macrophytes that includes *Pistia stratiotes* (Araceae), *Ipomea pes-caprae* (Convolvulaceae), *Eichhornia crassipes* (Pontederiaceae). Whereas, the division of Pteridophyta had 2 species of aquatic macrophytes, this includes *Ceratopteris thalictroides* (Parkeriaceae) and *Salvinia molesta* (Salviniaceae). Lastly, the division of Tracheophyta had only 1 aquatic macrophyte, the *Euryale ferox* (Nymphaeaceae).

Table 1: The Division, Family, Species names of collected aquatic macrophytes in selected sites of Lumbocan River, Butuan City

Division	Family	Species
Magnoliophyta		
	Araceae	*Pistia stratiotes*
	Convolvulaceae	*Ipomea pes-caprae*
	Pontederiaceae	*Eichhornia crassipes*
Pteridophyta		
	Parkeriaceae	*Ceratopteris thalictroides*
	Salviniaceae	*Salvinia molesta*
Tracheophyta		
	Nymphaeaceae	*Euryale ferox*

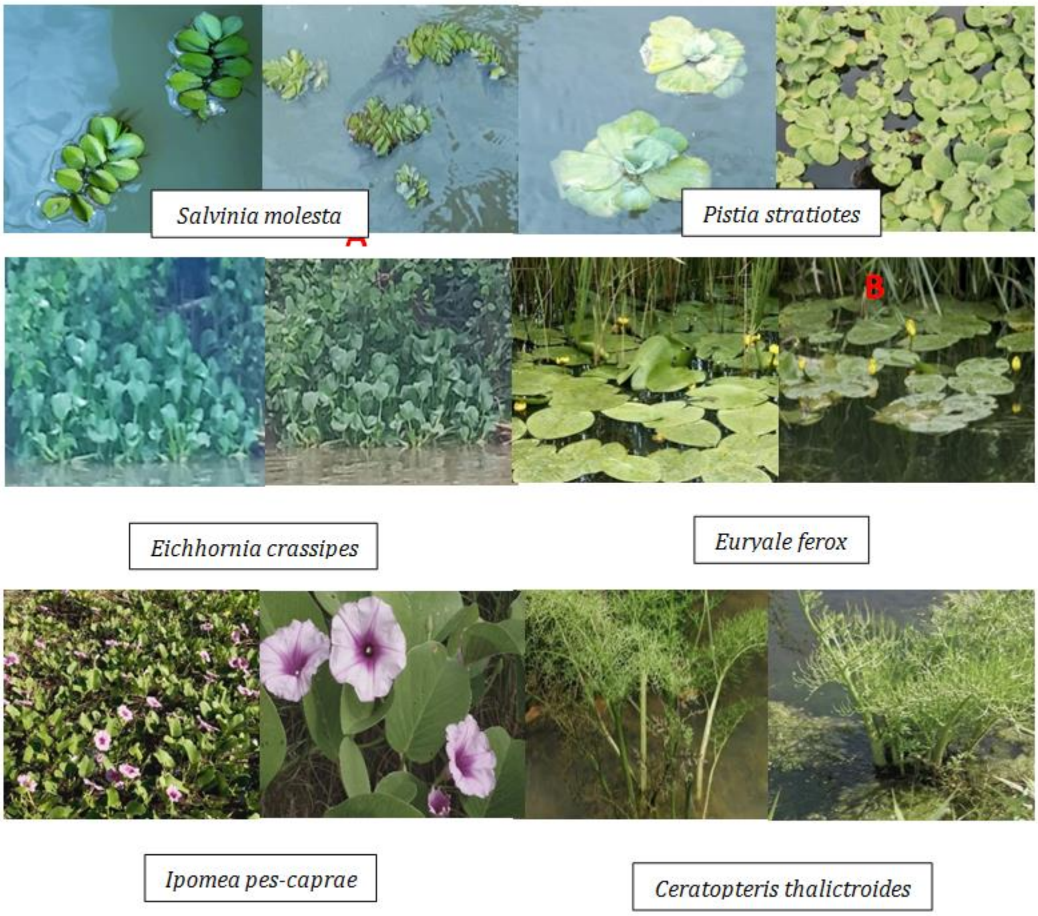

Figure 2: Collected aquatic macrophytes in selected sites of Lumbocan River, Butuan City

A total of 208 individual aquatic macrophytes was recognized as present in selected sites of Lumbocan River, Butuan City, Agusan del Norte, Philippines. In relation, the relative availability of water related-variables emerged as a major driver in explaining the level of species diversity of aquatic macrophytes observed in Lumbocan River. Hence, scientific reports have shown that habitats or an ecosystem having extended biodiversity have chances to adapt in the new environment and regrow from various ways (Sufia *et. al.*, 2019). As shown in table 2, the population of each aquatic macrophytes has great significant to the ecosystems. The

Pistia stratiotes, *Eichhornia crassipes*, *Euryale ferox*, and *Ipomea pes-caprae* have higher number of individual species observed in the study location. That means these aquatic macrophytes are most widely diverse species in the area. According to studies, dominant species or traits drive ecosystem functioning, and positive biodiversity ecosystem function relationships emerge simply because diverse communities are more likely to include high-functioning species, as explained by the selection effect hypothesis. It is thus necessary to assess how each species contributed to overall diversity and productivity, but our understanding has been limited primarily to macrophytes systems, particularly in the Philippines, being overlooked (Pasion *and his colleagues* 2021).

Table 2: Types of aquatic macrophytes observed in selected sites of Lumbocan River, Butuan City

Types of Aquatic Macrophytes	Number of Individual Species
Salvinia molesta	25
Pistia stratiotes	39
Eichhornia crassipes	43
Euryale ferox	27
Ipomea pes-caprae	52
Ceratopteris thalictroides	22
Total	**208**

Table 2 shows the types of aquatic macrophytes observed in selected sites of Lumbocan River, Butuan City. The most consistent observation of this study was the determination of aquatic macrophytes in the said location. Various aquatic macrophytes found in the area, these plant species are *Salvinia molesta* (25), *Pistia stratiotes* (39), *Eichhornia crassipes* (43), *Euryale ferox* (27), *Ipomea pes-caprae* (52), and *Ceratopteris thalictroides* (22). As shown in table 3, the aquatic macrophytes found in Lumbocan River has alike relative frequency. Additionally, several studies have shown the distribution and composition of macrophytes in some lakes or various aquatic ecosystem as a result of the interactions of several environmental variables, including abiotic, biotic, and anthropogenic factors (Minggagud *and his colleagues* 2013). Moreover, the ecosystems other than forests, such as river ecosystems, were not given much attention in floral assessment studies or any field. Despite the importance of these plants, very few studies on macrophyte diversity have been conducted.

Table 3: List of aquatic macrophytes present in Lumbocan River during the study period and their relative frequency

Species	Family	Common Name	Life Form	Relative frequency (%)
Pistia stratiotes	Araceae	Water lettuce	FL	0.19
Ipomea pes-caprae	Convolvulaceae	Goat's foot	F	0.25
Eichhornia crassipes	Pontederiaceae	Water hyacinth	F	0.21
Ceratopteris thalictroides	Parkeriaceae	Water sprite	S	0.11
Salvinia molesta	Salviniaceae	Kariba weed	F	0.12
Euryale ferox	Nymphaeaceae	Makhana	FL	0.13

Note: Abbreviations for life form: F: floating; E: emergent; FL: floating leaved; and S: submerged

Acording to the study of Svitok *and his colleagues* (2016), found that macrophyte diversity showed only a weak or has no relationship with spatial variables on several scales. Furthermore, he explained that the abundance of submerged and floating macrophyte species was not dependent on adjacent land use or on regional phytogeography in the prairie lotic environment (Rosso *and his colleagues* 2013). In a recent study of Murphy *and his colleagues* (2019), he stated that aquatic macrophytes were generally have narrow rather than broad world distributions.

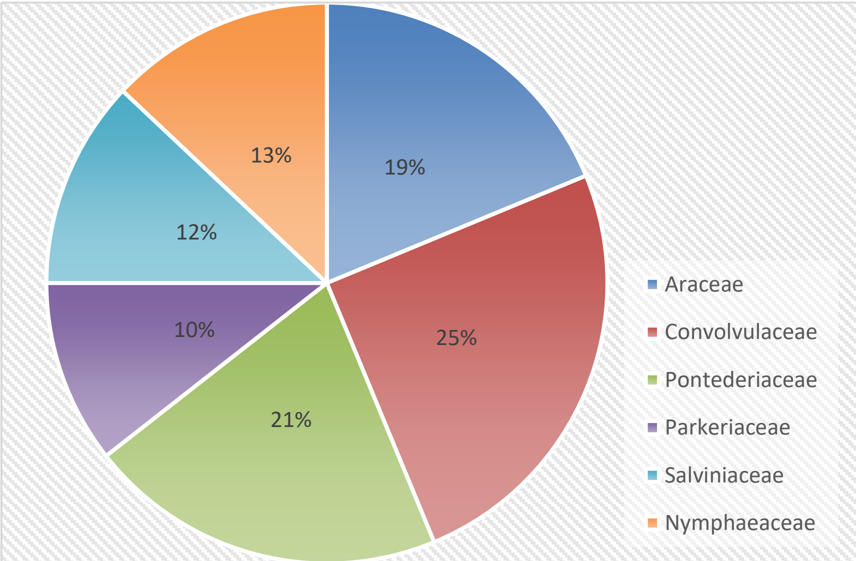

Figure 3: Graphical illustration showing the contribution of various families in total of aquatic macrophyte species abundance in Lumbocan River

The macrophyte survey revealed the occurrence of 6 aquatic macrophyte species belonging to 6 families. Macrophytes were characterized by the dominance of taxa belonging to the families, Convolvulaceae (25%), Pontederiaceae (21%), Araceae (19%), Nymphaeaceae (13%), Salviniaceae (12%), and Parkeriaceae (10%) (Figure 3). Based on the life form, the aquatic macrophytes were represented by 3 floating, 2 floating-leaved, and 1 submerged plant species (Table 3). Additionally, among the selected sites, the site 2 recorded the complete number of species (6 aquatic macrophytes) followed by site 3 (5 species) and site 1 were recorded least macrophyte species (3 species) in the area (Table 5).

In table 4, it illustrates the result of diversity index of aquatic macrophytes found in Lumbocan River, Butuan City. It was showed that Lumbocan River has diverse macrophyte species (1.745 medium diversity). Based on the findings, the first site near the roadway has 3 aquatic macrophyte species, namely *P. stratiotes*, *I. pes-caprae* and *S. molesta*. The second site were located at the middle point of the river and this site has the highest number of species (6 aquatic macrophytes). Lastly, the third site has 5 found macrophyte species such as, *P. stratiotes*, *I. pes-caprae*, *E. crassipes*, *C. thalictroides*, and *E. ferox* (Table 5).

The Shannon's diversity index is frequently utilized to assess the diversity. Herein, they make no assumptions about the shape and size of the underlying abundance distribution of aquatic macrophyte species in the study location. As shown on the result, the dominance of the plant species in the area (Lumbocan River), are greatly influenced by the most common species. Accordingly, species identify and well distributed which decorates community composition and affected by the environmental condition and water related-variables (Nsor *et. al.*, 2019). In the same manner, aquatic macrophyte species of different life forms are affected by dissimilar environmental factors (Garcia-Giron *et. al.*, 2014). The results show that the growth and distribution of aquatic macrophytes was inhibited significantly by water depth and related-variables. The researchers identified common conservation priorities among the species population, also, the adaptation of trait considered. Then, the researchers linked the gathered data of aquatic macrophyte species by calculated its diversity index (1.745) (Table 4).

Table 4: Shannon's Diversity index of aquatic macrophytes found in Lumbocan River, Butuan City

Species	**Number (p)**	**p*i***	***Ln*(p*i*)**	**p*i*****Ln*(p*i*)**	**- p*i*****Ln*(p*i*)**
Pistia stratiotes	39	0.188	-1.674	-0.314	0.314
Ipomea pes-caprae	52	0.250	-1.386	-0.347	0.347
Eichhornia crassipes	43	0.207	-1.576	-0.326	0.326
Ceratopteris thalictroides	22	0.106	-2.246	-0.238	0.238
Salvinia molesta	25	0.120	-2.119	-0.255	0.255
Euryale ferox	27	0.130	-2.042	-0.265	0.265
					1.745

Note: <1.5 = low diversity; 1.5-2.5 = medium diversity; > 2.5 = high diversity

Table 5: Diversity of aquatic macrophytes at all the selected sites

Species	**Site 1**	**Site 2**	**Site 3**
Pistia stratiotes	+	+	+
Ipomea pes-caprae	+	+	+
Eichhornia crassipes	-	+	+
Ceratopteris thalictroides	-	+	+
Salvinia molesta	+	+	-
Euryale ferox	-	+	+

Note: Presence (+); Absence (-)

In the diagram showing the sampling sites on macrophyte species similarity and abundance during the study period. Along the selected sites fluctuating between 0.50 (site 1) and 0.83 (site 3) (Figure 4). Based on this, the researchers can identify aquatic species that are reliable indicators of changes in river ecosystems and utilize them as a tool to assess the ecological status of rivers (Aznar *and his colleagues* 2002).

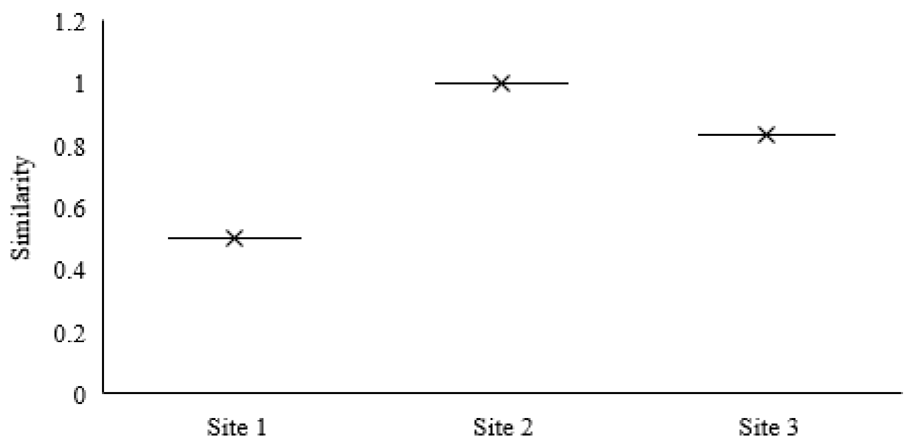

Figure 4: The diagram showing of sampling sites based on species similarity and abundance during the study period.

In Table 6, it was shown that most of the surveyed aquatic macrophyte species were not yet assessed by the International Union for the Conservation of Nature due to its abundance in the field (IUCN, 2015). In relation,1 macrophyte species *(E. ferox)* were regarded as least concern. Hence, the 5 macrophyte species are included to the Red List of Threated Species (IUCN, 2015), these were *Pistia stratiotes, Ipomea pes-caprae, Eichhornia crassipes, Ceratopteris thalictroides,* and *Salvinia molesta*. These aquatic macrophytes were distributed from several parts of the world and were not yet assessed due to wide range of distribution which can be harmful to the aquatic ecosystem that might causes a widespread unhealthy condition for cultivation (Madsen, 2004). Accordingly, if there are rare and threatened species in an area or location it requires greatly specific management practices and procedures (Jayatissa *and his colleagues* 2002).

Table 6: The Distribution and Conservation Status of aquatic macrophyte species in Lumbocan River

Family	**Common Name**	**Scientific Name**	**Conservation Status**	**Distribution Status**
Araceae	Water lettuce	*P. stratiotes*	NYA	NE
Convolvulaceae	Goat's foot	*I. pes-caprae*	NYA	NE
Pontederiaceae	Water hyacinth	*E. crassipes*	NYA	NE
Parkeriaceae	Water sprite	*C. thalictroides*	NYA	NE
Salviniaceae	Kariba weed	*S. molesta*	NYA	NE
Nymphaeaceae	Makhana	*E. ferox*	LC	N

*IUCN status: NYA = Not Yet Assessed; NE = Non-Endemic; LC = Least Concern; N = Native

4. Conclusion

The study provides information regarding the aquatic macrophyte composition and diversity in selected sites of Lumbocan River, Butuan city. A total of 6 species aquatic macrophytes belonging to 6 families and 3 divisions were collected and plainly identified at the study location. The division of Magnoliophyta had three-identified aquatic macrophytes that includes *Pistia stratiotes* (Araceae), *Ipomea pes-caprae* (Convolvulaceae), *Eichhornia crassipes* (Pontederiaceae). Whereas, the division of Pteridophyta had 2 species of aquatic macrophytes, this includes *Ceratopteris thalictroides* (Parkeriaceae) and *Salvinia molesta* (Salviniaceae). Lastly, the division of Tracheophyta had only 1 aquatic macrophyte, the *Euryale ferox* (Nymphaeaceae). Hence, diversity index of aquatic macrophytes found in Lumbocan River, Butuan City was showed species medium diversity of 1.745 because most likely the macrophyte communities were similar in all transects. Based on the findings, the first site near the roadway has 3 aquatic macrophyte species, namely *P. stratiotes*, *I. pes-caprae* and *S. molesta*. The second site were located at the middle point of the river and this site has the highest number of species (6 aquatic macrophytes). Lastly, the third site has 5 found macrophyte species such as, *P. stratiotes, I. pes-caprae, E. crassipes, C. thalictroides*, and *E. ferox.* These macrophyte species were distributed within the selected sampling sites, and human activities such as urbanization and industrialization or might be a road widening were the possible threats that could affect or has an impact to macrophytes community. This study might be used as a baseline for future research, specifically in the context of the ecosystem services, sustainable macrophytes species monitoring and conservation programmes.

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