Aquatic plants and benthic biodiversity: a comprehensive study of community interactions in Aneuk Laot Lake, Sabang

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Abstract. Aquatic plants, as primary producers, play a crucial role in aquatic ecosystems, and macrozoobenthos also contribute significantly to the nutrient cycles at the water's bottom. This research aims to identify and analyze aquatic plants and macrozoobenthos in Aneuk Laot Lake, Sabang. This research uses a descriptive method by analyzing the diversity index, uniformity index, dominance index and species abundance. The research results show that there are 3 families, 5 species and 94 individuals of aquatic plants. The most dominant species is *Eichhornia crassipes* from the Pontederiaceae family. The abundance value of aquatic plants in Lake Aneuk Laot ranges from 13-26 individuals/m^2. The aquatic plant diversity index ranges from 1.48-1.58, which indicates the medium category. The aquatic plant uniformity index ranges from 0.92-0.98 which indicates the stable category and the dominance value ranges from 0.21-0.24 which indicates the low category. The macrozoobenthos composition consists of 3 classes, 7 species and 82 macrozoobenthos individuals. The most dominant species is *Anodonta woodiana* from the Unionida family. The highest abundance in macrozoobenthos ranges from 5-23 individuals/m^2. The macrozoobenthos diversity index ranges from 0.95-1.46 which indicates the medium category. The uniformity value ranges from 0.87 to 0.91, which is in the high category, and the dominance index ranges from 0.26 to 0.40, indicating good stability in the macrozoobenthos community. The value of the commodity structure of aquatic plants and macrozoobenthos shows that water conditions are stable and the diversity index of aquatic plants and macrozoobenthos is classified as moderate, uniformity is still evenly distributed and there are no dominant species.

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1 Introduction

Aneuk Laot Lake is the second largest lake in Aceh, located in Sabang City. Aneuk Laot Lake plays an important role in the lives of the surrounding community, serving as a source of drinking water (provided by the PDAM) for Sabang City residents. In addition, it is utilized as a fishing area by local fishermen, a water source for agriculture, and for other needs[1, 2]. Over the past 10 years, Aneuk Laot Lake has experienced a continuous decline in water levels, raising concerns about the availability of raw water for the community and potential issues with the lake's ecosystem [3, 4]. Organisms that significantly impact the lake's ecosystem include aquatic plants and macrozoobenthos.

Aquatic plants are plants that grow in water or spend most of their lives in aquatic environments, forming an essential part of aquatic ecosystems [5]. The presence of healthy aquatic plants supports high aquaculture productivity and diverse aquatic biota [6]. One group of aquatic plants from the Lamiaceae family, commonly known as duckweed (Wolffia), has long been recommended as a natural feed source for fish farming [7]. In addition to aquatic plants, Aneuk Laot Lake also hosts an abundance of diverse macrozoobenthos, which play a vital role in maintaining the lake's aquatic ecosystem.

Macrozoobenthos are one of the most important groups in an ecosystem. They can break down large organic materials into smaller particles, making it easier for microbes to decompose them [8]. Macrozoobenthos play a crucial role in neutralizing aquatic environments by converting organic waste into their food source, thereby stabilizing water conditions [9]. Their presence in aquatic ecosystems is essential, as they serve as a natural food source for fish and other predators while contributing to the decomposition of organic matter [10]. Additionally, they act as a vital link in the energy flow and the planktonic algae cycle, supporting higher-level consumers. The continuous decline in water levels is suspected to affect macrozoobenthos organisms and aquatic plants, which serve as bioindicators of the Aneuk Laot Lake ecosystem.

One of the macrozoobenthos groups identified as an invasive species in Aneuk Laot Lake is *Cherax quadricarinatus*. The presence of invasive species is recognized to potentially eliminate the biodiversity of native aquatic fauna. The presence of this invasive species is detrimental not only economically but also ecologically, as invasive species disrupt communities through various mechanisms, including competition, predation, parasitism, hybridization, nutrient cycling, and habitat alteration. Therefore, this study aims to assess the current biodiversity conditions in Aneuk Laot Lake, particularly the diversity of aquatic plants and macrozoobenthos, as a strategy for the conservation and management of Aneuk Laot Lake in the future.

2 Methodology

2.1 Sampling area

This research was conducted from March to June 2024 at Aneuk Laot Lake, Sabang City. Sample identification was carried out in the Marine Biology Laboratory of the Faculty of Marine and Fisheries, Syiah Kuala University. The research location is illustrated on Map Fig 1.

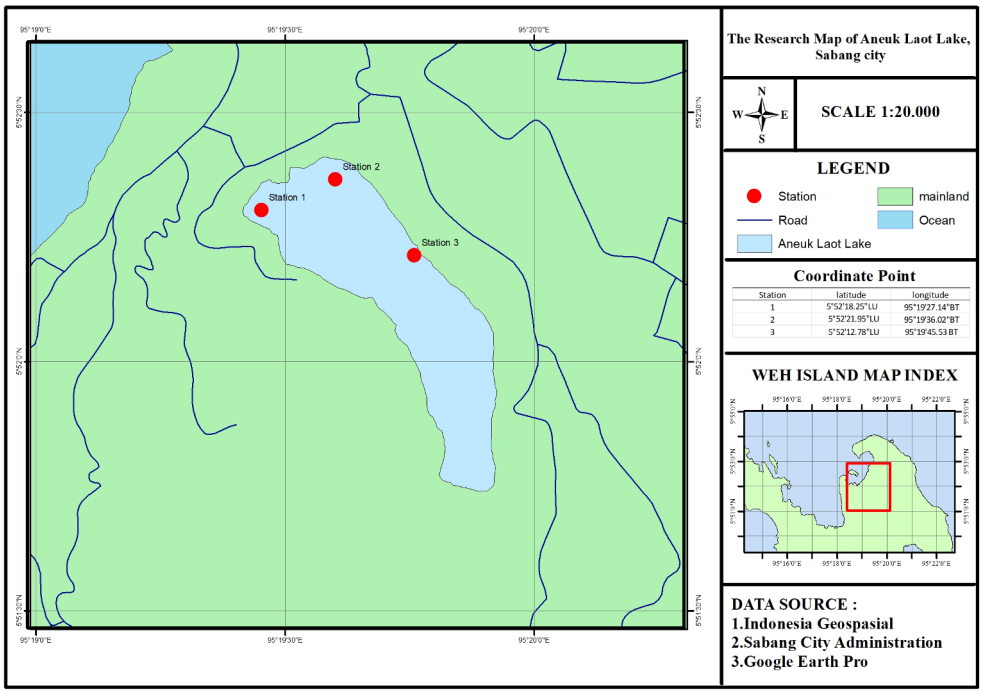

Fig. 1. The research map of the Aneuk Laot Lake Waters.

2.2 Research procedure

The determination of observation station points for aquatic plants and macrozoobenthos was conducted using the purposive sampling method, consisting of 3 observation stations with 3 repetitions at each station. The sampling locations were selected based on the presence of aquatic plants. Samples of aquatic plants and macrozoobenthos were collected using a 1x1 meter quadrat transect method, which was placed within clusters of aquatic plants. The identification of aquatic plant species referred to [11, 12], while the identification of macrozoobenthos used the references by [13, 14]

2.3 Data analysis

The data obtained in this study were analyzed descriptively. The research parameters observed include the abundance of aquatic plants and macrozoobenthos, referring to [15], the species diversity index by Shannon–Wiener [16], the evenness index by [17], and the species dominance index by Simpson [16].

3 Result

3.1 Composition and abundance of aquatic plants

The aquatic plants identified in the waters of Aneuk Laot Lake, Sabang City, consist of five species: *Sagittaria latifolia*, *Cyperus rotundus*, *Actinoscirpus grossus*, *Eichhornia crassipes*, and *Limnocharis flava*. These aquatic plants are categorized as floating plants and partially submerged plants. Some of the identified aquatic plant species are presented in Fig 2.

Fig. 2. The Graphs of aquatic plants identified in Aneuk Laot Lake, Sabang City

The abundance of aquatic plants found in Aneuk Laot Lake is presented in Table 1.

Table 1. The abundance of aquatic plants found in Aneuk Laot Lake.

Species	**Abundance of aquatic plant (ind/m^2)**		
	Station 1	**Station 2**	**Station 3**
Sagittaria latifolia	9	4	1
Cyperus rotundus	6	2	5
Actinoscirpus grossus	8	5	7
Eichhornia crassipes	12	6	8
Limnocharis flava	7	9	5

3.2 Composition and abundance of macrozoobenthos

The macrozoobenthos species identified in the waters of Aneuk Laot Lake, Sabang City, belong to six families: Thiaridae, Ampullariidae, Nassariidae, Unionidae, and Parastacidae. The graphs of the macrozoobenthos species found in Aneuk Laot Lake are presented in Figure 3.

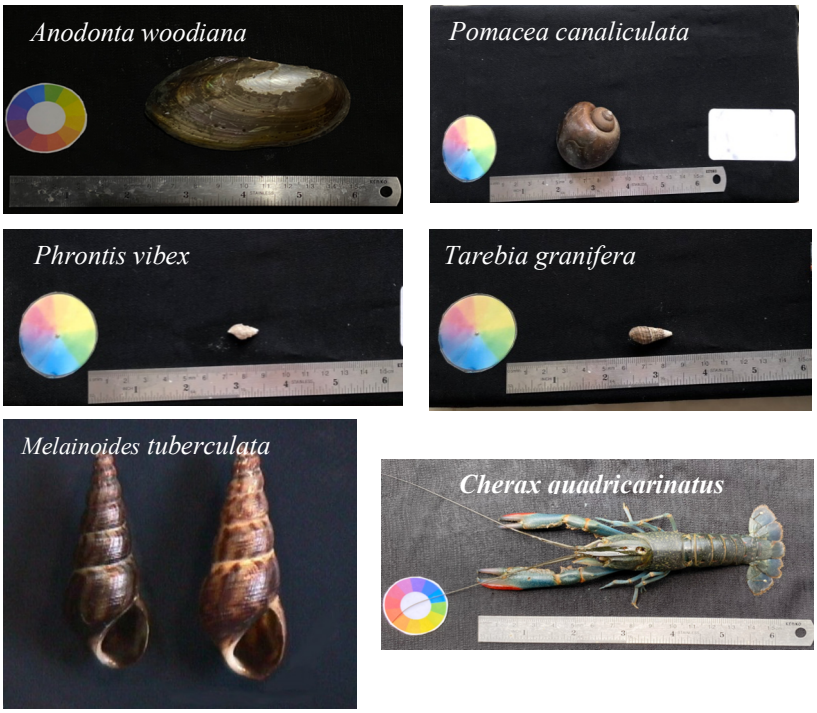

Fig. 3. The graphs of the macrozoobenthos species found in Aneuk Laot Lake.

The abundance of macrozoobenthos in Aneuk Laot Lake is presented in Table 2.

Table 2. The abundance of macrozoobenthos in Aneuk Laot Lake.

Species	The abundance of macrozoobenthos (ind/m^2)		
	Station 1	Station 2	Station 3
Melainoides tuberculata	5	1	0
Pomacea canaliculata	3	0	1
Tarebia granifera	8	5	0
Phrontis vibex	3	2	0
Anodonta woodiana	0	1	22
Cherax quadricarinatus	12	4	6

3.3 The community structure of aquatic plants and macrozoobenthos

In this study, the diversity index of aquatic plants was found to be equal to that of macrozoobenthos. The diversity of both aquatic plants and macrozoobenthos is categorized as moderate. The community structure of aquatic plants is presented in Table 3 and the community structure of macrozoobenthos is presented in Table 4.

Tabel 3. The community structure of aquatic plants.

Structure Community	Station 1	Station 2	Station 3
Diversity Index(H')	1.58	1.51	1.48
Evenness Index (E)	0.98	0.94	0.92
Dominance Index (C)	0.21	0.24	0.24

Tabel 4. The community structure of makrozoobenthos

Structure Community	Station 1	Station 2	Station 3
Diversity Index(H')	1.46	1.41	0.95
Evenness Index (E)	0.91	0.88	0.87
Dominance Index (C)	0.26	0.29	0.40

4 Discussion

In this study, the aquatic plant *Eichhornia crassipes* exhibited the highest cover percentage, reaching up to 60%, compared to the other five species. Water hyacinth (*Eichhornia crassipes*) has significantly reduced water availability and threatened the livelihoods of the Aneuk Laot Lake community, who depend on fishing. *Eichhornia crassipes* has a rapid growth rate and can reproduce both sexually and asexually, allowing it to spread quickly over large areas. This species is highly adaptable to various water conditions and thrives across a wide range of nutrient levels, often dominating other aquatic plant species in the lake [18-20]. Its tolerance to pollution and ability to store high levels of nutrients make it resilient in disturbed environments. It is commonly found in eutrophic or nutrient-rich waters, where other species may struggle to survive.

The aquatic plant diversity index in Aneuk Laot Lake is categorized as moderate, with values ranging between 1.48 - 1.58. A community can be said to have high species diversity when there is a relatively even distribution of individuals among species. [21] further explained that the presence of well-adapted aquatic plants can create aquatic environments with high productivity and, consequently, high aquatic biodiversity. The evenness index for aquatic plants in Aneuk Laot Lake, Sabang, was found to range between 0.92 and 0.98. The evenness values at each station fall into the stable category. This stability is attributed to the relatively similar number of individuals across species. According to [22], smaller evenness index values indicate greater differences in the number of individuals between species, whereas larger evenness index values reflect smaller differences, reducing the likelihood of one species dominating over others. The dominance values at each station were categorized as low. According to [23], the dominance index is used to assess species richness and the balance of individual numbers among species within an ecosystem. This is supported by the findings of [24], who stated that dominance refers to a primary plant species that influences and controls the community through its abundance, size, or dominant growth.

In this study, the most abundant species identified were *Anodonta woodiana* and the freshwater crayfish (*Cherax quadricarinatus*). The presence of *C. quadricarinatus* as an invasive species poses a threat to other benthic populations [25-27]. Common socio-

economic impacts of this invasive species include damage to fishing gear and a decline in fisheries performance. Ecological impacts are associated with direct consumptive effects, multi-trophic impacts, and indirect competition, particularly with macroinvertebrates, as well as the potential spread of parasites [28]. *C. quadricarinatus* exhibits sexual dimorphism, with significant variations in carapace length, chela length, and chela width between males and females. Fecundity depends on size, with large females found year-round in Jamaica. According to research by [27], *C. quadricarinatus* is an opportunistic omnivore, with minimal differences in dietary patterns across gender classes, sizes, temporal, or spatial scales. While gastropod predation is size-selective and shows a preference for certain species (e.g., those from the Thiaridae family over native snails from the Physidae family), stomach content analysis revealed that gastropods are not the primary food source for this crayfish. Detritus constitutes the main component of *C. quadricarinatus*'s diet, though under experimental conditions, the species showed a preference for macrophytes. This dietary preference can indirectly affect benthic invertebrate communities by reducing the availability of food and vegetative substrates. The macrozoobenthos diversity index is categorized as moderate, with a stable evenness index, as indicated by the absence of a dominant species. Several management recommendations derived from the study include implementing a control program for *Cherax quadricarinatus* using methods such as selective harvesting, regular population monitoring, and the removal of habitats that facilitate its spread. It is also essential to develop data-driven policies to prevent the introduction of new invasive species, such as enforcing quarantine regulations and strict inspections of fisheries activities. Furthermore, the rehabilitation of natural habitats is crucial to support native species by replanting lost aquatic vegetation and minimizing destructive human activities.

5 Conclusion

The conclusions of this study indicate that the aquatic conditions in Aneuk Laot Lake remain relatively stable. This is evidenced by the moderate diversity index of aquatic plants and macrozoobenthos, an evenness index indicating a balanced distribution, and the absence of dominant species. The highest abundance of aquatic plants was observed in *Eichhornia crassipes*, it has the highest cover percentage, reaching up to 60%. Among macrozoobenthos, the highest abundance was recorded for *Anodonta woodiana*, with 23 individuals/m². The findings of this study serve as a foundation for developing a regional framework using an ecosystem-based approach to lake management, which includes pollution control, long-term monitoring, and the integration of local communities in conservation efforts.

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