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Analysis of plankton abundance and diversity in Tamarupa Coastal Waters, Pangkep Regency, Indonesia

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Abstract

The study aimed to determine the level of plankton diversity at the study site and its relationship to milkfish cultivation development. This study was a survey study, taking three observation stations (ST) with different location characteristics. The research parameters were plankton quantity, abundance, diversity, uniformity, and dominance. The results of the study showed that the number and abundance of plankton were *Chlamydomonas* sp. plankton found in ST1, which is a location in the Tamarupa River Estuary. Plankton diversity showed that in ST 1 the highest diversity was *Nitzschia* sp., in ST 2 it was *Navicula* sp., and in ST 3 it was *Chlamydomonas* sp. The plankton uniformity value at the highest research location was in ST 2, which was 0.151358456. Furthermore, the dominance value of *Chlamydomonas* sp. plankton is found in ST 1, and *Pleurosigma* sp plankton is found at ST 3.

Keywords: Abundance; Diversity; Plankton; Coast; Tamarupa

1. Introduction

There are many natural resources in coastal seas that can be used profitably, fisheries, mining, shipping, oil and gas production, tourism, and recreation all depend on coastal seas for their resources (Zheng & Klemas, 2018), and Tamarupa Beach is one of the beaches in Pangkep Regency. Tamarupa Village, Mandalle District, is a coastal area in the Mandalle District, where numerous activities can impact water and soil quality, particularly in relation to fish farming development. This area is home to numerous mangrove forests, fish ponds, and fishing activities, all of which can cause environmental damage. This area also has several tributaries that are widely used by the community for fish farming, agriculture, and other purposes. Particularly in the upper reaches of the river, there are rice fields where chemical cultivation practices produce waste. These farmlands use heavy fertilizers, so when some of this fertilizer is washed away by rainwater, the agricultural wastewater enters the water bodies. This naturally contributes waste or chemical residue to the river and can impact its water quality.

Human activity happens along rivers in addition to upstream areas, especially in residential areas. The direct disposal of some domestic garbage into rivers can have a detrimental effect on the quality of the water. Pollutants can be introduced by routine human activity. Aquatic ecosystem dynamics are greatly influenced by environmental carrying capacity and community structure. Plankton is one of the creatures in aquatic ecosystems, and the more stable the environment, the more stable the aquatic ecosystem (Hasanah et al., 2014).

The abundance of plankton, which are aquatic organisms, may be a sign that the ecological quality of river waters has changed. The primary productivity of river waters is significantly influenced by plankton. Perhaps the ancestors of life on Earth, plankton are essential to marine ecosystems. Because they are autotrophic, they can create oxygen, which is vital to the existence of higher species, and transform inorganic nutrients into organic matter (Usman et al., 2013). Some

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plankton organisms are tolerant and respond differently to changes in water quality. One approach is to use the saprobic index, which is used to determine the level of dependence or relationship of an organism with the compounds that serve as its nutritional source. This index allows for the relationship between plankton abundance and the level of pollution in a body of water (Hutabarat et al., 2013). The presence of plankton is crucial for aquatic ecosystems (Kusriyati et al., 2024).

Plankton plays a vital role in marine ecosystems as primary producers, the base of the food chain and food web, and is often used as a bioindicator to monitor water conditions (Idiawati et al., 2021; Yusuf et al., 2020). Plankton is a group of aquatic biota, both plants and animals, that live floating or drifting passively on the water surface and whose movement and distribution are influenced by currents, even if very weak (Daniaty et al., 2020). With the help of phytoplankton, which are capable of producing organic matter through photosynthesis, the life cycle in the waters begins and continues until it reaches a larger organism level. Plankton can then be used as an indicator of the level of water fertility, meaning that the more plankton there is, the more abundant the food source for fish will be (Wiadnyana, 2006, in Madjid et al., 2025). According to Nybakken (1992), plankton is very important for the marine economy because plankton is the initial binder of solar energy. Phytoplankton are also the main producers (primary producers) in aquatic ecosystems (Linus et al., 2016). Plankton is very important for the marine food chain and ecosystem balance (Madjid et al., 2025).

According to Prastyaningtyas et al. (2012), plankton are divided into two groups: phytoplankton and zooplankton. Phytoplankton are plant-like members of the plankton. They are found in water masses with light intensity that can penetrate the water and act as primary producers in the water. Plankton, consisting of phytoplankton (plant plankton) and zooplankton (animal plankton), are the main components in the marine life cycle (Ayuni, 2023). Phytoplankton and zooplankton are key components of coastal waters due to their ecological function as primary producers and their role as environmental indicators. Phytoplankton, in particular, act as primary producers, supporting the aquatic food chain and providing oxygen, while zooplankton act as a link between producers and consumers (Indrayani et al., 2023). Zooplankton, on the other hand, are primary consumers, utilizing the primary production produced by phytoplankton. The role of zooplankton as primary consumers, connecting phytoplankton with small and large carnivores, can influence the complexity of the food chain within an aquatic ecosystem. Zooplankton, like other organisms, only thrive in optimal water conditions. The distribution patterns and community structure of zooplankton in a body of water can be used as biological indicators to determine changes in water conditions (Suherman, 2005). One community that influences the presence of plankton is the mangrove. Mangrove ecosystems are fertile aquatic areas because the trees have the potential to produce productive organic matter through their leaf litter. After undergoing a decomposition process by bacteria and protozoa, minerals such as nitrogen, phosphorus, and other nutrients are produced (Heriyanto, 2012).

There is a great deal of opportunity for pond development, and milkfish farming is possible along almost all of Indonesia's beaches. Because of its tasty flavor and high protein content, milkfish is still a vital product in pond farming (Hamdani, 2007). In coastal regions, brackish water aquaculture uses ponds as a sort of habitat (Suparjo, 2008). A common problem in coastal areas is pollution, which reduces the carrying capacity and biological resources of the coast and sea (Hamuna et al., 2018). Various anthropogenic activities along the coast, such as settlements, fisheries cultivation, and maritime transportation, have the potential to produce pollutants in the form of organic and inorganic waste (Utomo et al., 2014). Plankton's sensitivity to environmental changes makes it a valuable indicator of environmental quality (Shabrina et al., 2020).

According to Ashari (2011), pond cultivation is currently considered a business that can generate extraordinary income. This trend is justified, as it has been proven that newly opened land can produce yields, even for farmers with low to moderate levels of technological expertise. One of the fishery species frequently cultivated in ponds is milkfish. This fish grows relatively quickly and is popular due to its affordable price. Milkfish contains higher levels of animal protein than plant-based protein (Murtidjo, 2002). According to Muntalim (2014), milkfish as a cultivated commodity has advantages such as being able to grow well in traditional ponds, being herbivorous, resistant to disease, and being harvestable twice a year. Milkfish feed according to their mouth opening. This has been adapted for cultivation, which utilizes collection of algae as natural food. Milkfish cultivation has also utilized artificial feed (pellets) (WWF Indonesia, 2014). According to Aqil (2010), the natural food of milkfish in their natural habitat includes phytoplankton, zooplankton, aquatic plants, and detritus. The stomach contents of juvenile milkfish are dominated by algae of the single-celled algae type (Chlorophyta), single-celled and filamentous cells (Cyanophyta), diatoms, crustaceans, ciliates, dinoflagellates, rotifers, and the largest is detritus. Meanwhile, milkfish cultivated in ponds are usually better known as klekap-eating fish, namely complex life dominated by blue algae (Cyanophyceae) and grit algae (Chrysophyceae) (Kordi, 2010).

According to Sitorus (2009), phytoplankton is a crucial element in the development of brackishwater or pond fisheries. Phytoplankton are biotic components that play a role in transferring energy to higher trophic levels of organisms. One factor that significantly influences phytoplankton growth is the nutrient supply in a body of water. The abundance of plankton will influence the growth of milkfish. According to Aqil (2010), milkfish are planktivorous at all stages of their life, feeding during the day. Their natural habitat is the sea, but they have been developed to be cultivated in brackish water. Tamarupa Waters, Mandalle District, Pangkep Regency, is a coastal area where, in or around it, there are many milkfish ponds owned by farmers, mangrove forests, and small river estuaries that are directly connected to the sea, so it was necessary and has been carried out a study related to the existence of plankton as one of the natural food sources for milkfish.

2. Materials and methods

This research was conducted from February to March 2026 and was located on the coast of Tamarupa Beach, Mandalle District, Pangkep Regency, where plankton testing was carried out at 3 stations (ST), namely, sampling point station 1 (ST 1) is located at the Tamarupa River estuary; sampling point station 2 (ST 2) is located in the mangrove vegetation; and sampling point station 3 (ST 3) is located around the fishponds and rice fields in Tamarupa Village.

Sampling was conducted six times at each station with one-week intervals. This study used a survey method by taking water samples from the river, filtering them using a plankton net, and then observing them in the laboratory using a microscope. The tools used in this study were sample bottles, plankton nets, microscopes, volumetric flasks, measuring cylinders, analytical pipettes, buckets, cool boxes, and writing utensils. Meanwhile, the materials used in this study were sea/river water, distilled water, and Lugol's. Plankton sampling was carried out using a plankton net. The plankton net has a mesh size of 25 microns. Plankton samples were then placed in sample collection bottles and treated with Lugol's preservative before being transported to the laboratory for analysis. Each sample bottle was labeled based on the sampling location (Dewanti et al., 2018). Plankton sample testing consisted of plankton quantity, abundance, diversity, uniformity, and dominance. The data obtained were then collected and analyzed using descriptive analysis.

3. Results and discussion

3.1 Amount of Plankton

Phytoplankton populations constantly experience fluctuations in composition and quantity due to differences in water quality (especially nutrients) and also due to grazing by zooplankton and herbivorous fish and the accumulation of toxic metabolic waste (Makmur et al., 2012). Based on Figure 1, it can be seen that the largest number of plankton at the research site was the *Chlamydomonas* sp. species. *Chlamydomonas* sp. is often found in waters due to its excellent biological adaptability, metabolic flexibility, and rapid reproductive ability and is one of the unicellular green microalgae that dominates aquatic ecosystems. The results of this study indicate that at the research site there are various types of plankton, although the numbers are not too large but are still able to support milkfish cultivation at the research site.

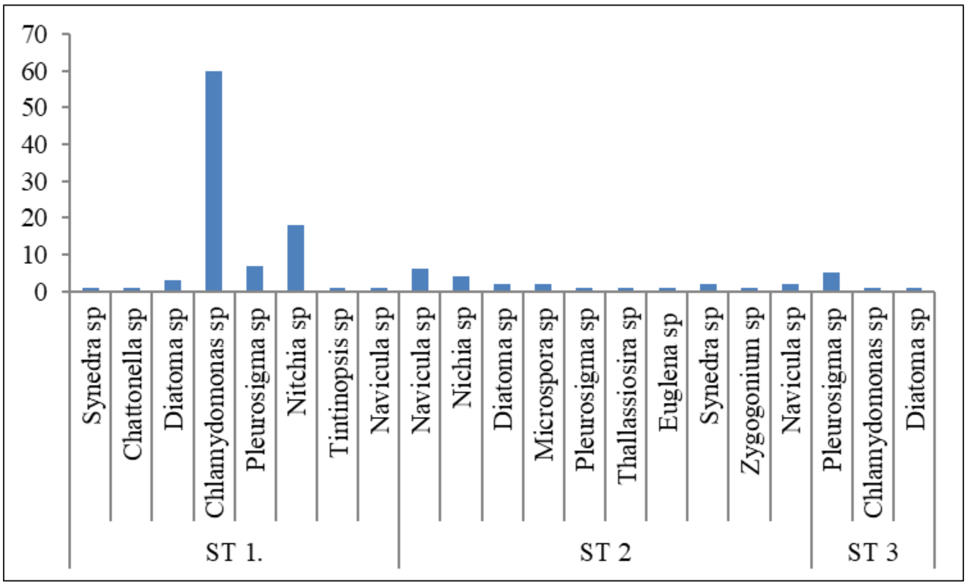

Figure 1 Amount of Plankton at the Research Location

3.2 Plankton Abundance

A thorough understanding of plankton abundance and diversity is key to designing effective conservation policies and managing marine natural resources (Tambaru et al., 2018). Plankton abundance is a crucial determinant of the survival and development of fish populations (Nindarwi et al., 2019), so understanding plankton dynamics in this region will provide valuable insights for sustainable fisheries management (Diana et al., 2023).

Based on Figure 2, it can be seen that the highest abundance of plankton at the research site was *Chlamydomonas* sp. Some experts believe that *Chlamydomonas* sp. can reproduce rapidly through cell division (asexually), has rapid reproduction, and allows its population to increase rapidly in a short time. There is a positive relationship between phytoplankton abundance and aquatic productivity. If phytoplankton abundance in a body of water is high, then the body of water tends to have high productivity as well (Yuliana et al., 2012). The abundance of plankton genera in waters fluctuates depending on the season. Some plankton genera are abundant during the dry season, while others are abundant during the rainy season. These fluctuations are influenced by several factors, including temperature, pH, nutrient concentration, light, weather, disease, and fish and zooplankton predation (Utojo, 2015). Furthermore, organic and inorganic materials can affect plankton abundance and diversity. The environment in which plankton live varies greatly, influenced by temporal changes such as temperature, nutrients in the water, and light entering the water (Amelia et al., 2012). Plankton abundance at the research location is still relatively low, but it can still support milkfish cultivation.

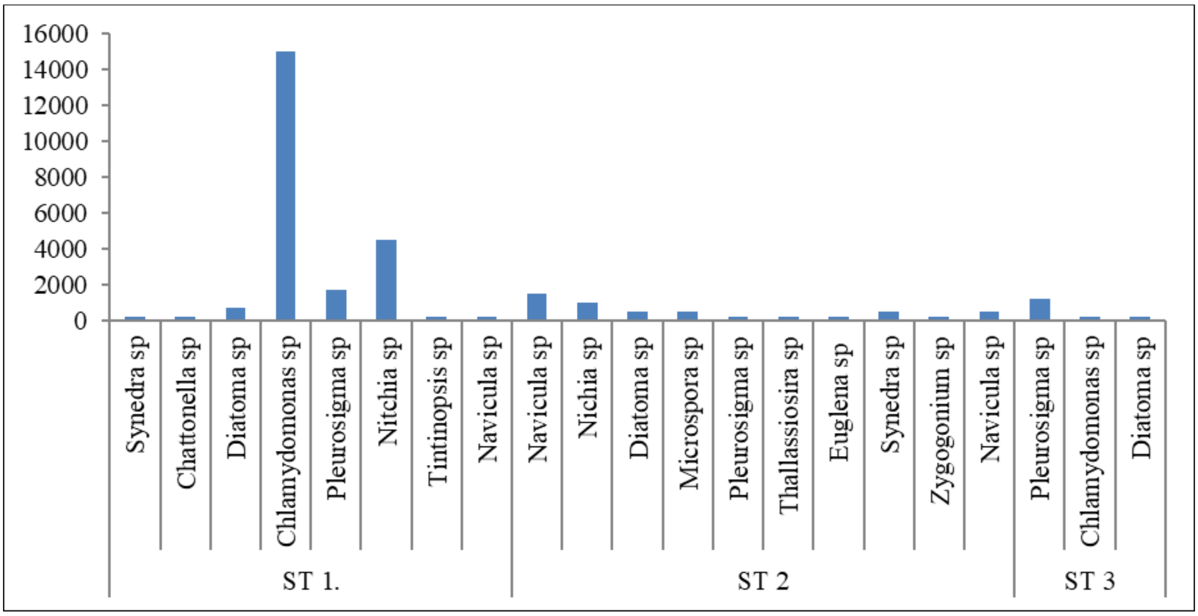

Figure 2 Plankton Abundance at the Research Location

3.3 Plankton Diversity

Plankton diversity reflects the level of productivity and quality of a body of water (Yusuf et al., 2020), and the value of this diversity index is related to the number of species present in the community, which can vary within a certain range, as stated by Failu et al. (2021). Hardiyanti et al. (2019) stated that the higher the diversity value, the more organisms inhabit the area. Therefore, the diversity index is an important indicator for understanding the diversity and health of aquatic ecosystems. The highest plankton diversity was found in the *Navicula* sp. species found in ST 2, at 0.354349905. Some experts argue that the high number of *Navicula* sp. in water is caused by *Navicula* sp. having high environmental adaptability and having a high reproductive rate if supported by sufficient nutrition, and this type of plankton is widely distributed in various aquatic ecosystems so that it is often used as natural food in milkfish cultivation ponds. Utojo (2015) stated that the diversity and stability of plankton in traditional ponds are also influenced by the habitat of plankton and cultivated commodities; besides that, it is necessary to leave mangrove plants as green paths and natural filters along rivers, main channels, and between pond beds.

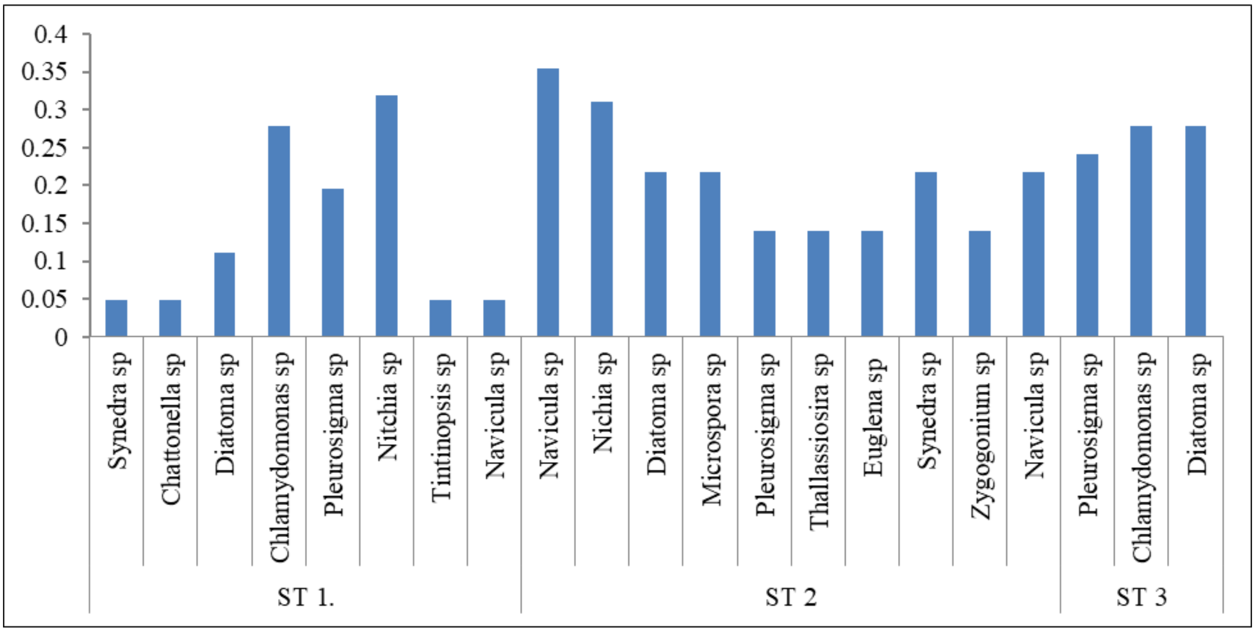

Figure 3 Plankton Diversity at Research Locations

3.4 Plankton Uniformity

Plankton uniformity at the three research locations was highest for *Chlamydomonas* sp., with a diversity of 0.278767836, followed by *Diatoma* sp., which had the highest diversity level at ST 3, in the mangrove vegetation area, with a diversity index of 0.277987164. Experts argue that water quality conditions can be closely related to the species diversity index. This is based on the understanding that environmental imbalance can affect the life of organisms in the water (Radia et al., 2024). The uniformity index of an organism community can reach its highest value if the distribution of the number of individuals in each species is relatively equal (Suriani, 2021).

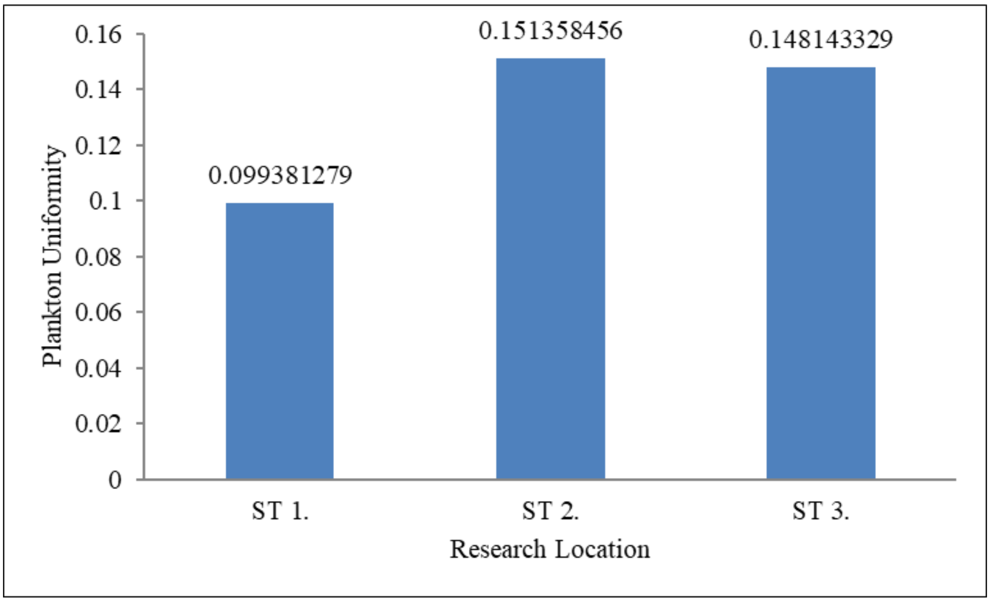

Figure 4 Uniformity of Plankton at Research Locations

3.5 Plankton Dominance

The highest plankton dominance was found in *Chlamydomonas* sp. plankton found in ST 1 and *Pleurosigma* sp. plankton found in ST 3. The dominance index shows the species richness in a community as well as the balance of the number of individuals of each species (Hidayat et al., 2015). Furthermore, Dinisia et al. (2015) stated that the dominance index value aims to determine whether or not there is a dominant species in a body of water. Handayani (2009) stated that the low dominance index value is thought to be related to tidal currents, which tend to evenly distribute the plankton population due to the plankton's inherent nature of being carried by currents. Furthermore, according to Yuliana et al. (2012), the dominance index reflects the presence or absence of a species that dominates other species. Experts believe that high plankton dominance in waters, particularly phytoplankton, occurs due to a combination of environmental factors that support rapid growth and the organisms' adaptability.

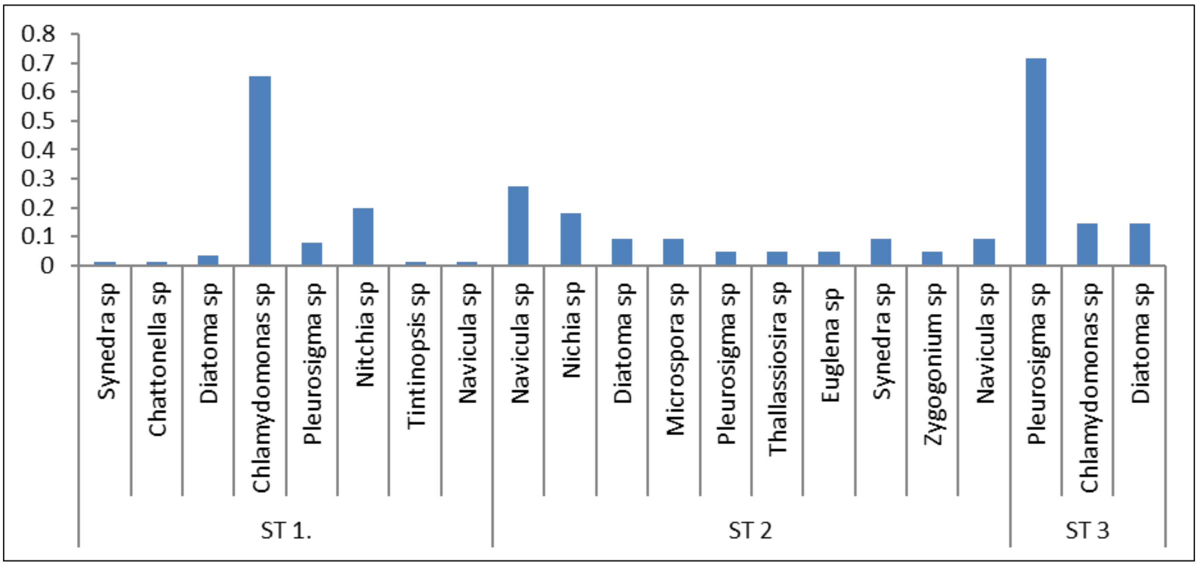

Figure 5 Plankton Dominance (ni/N) = pi) Research Location

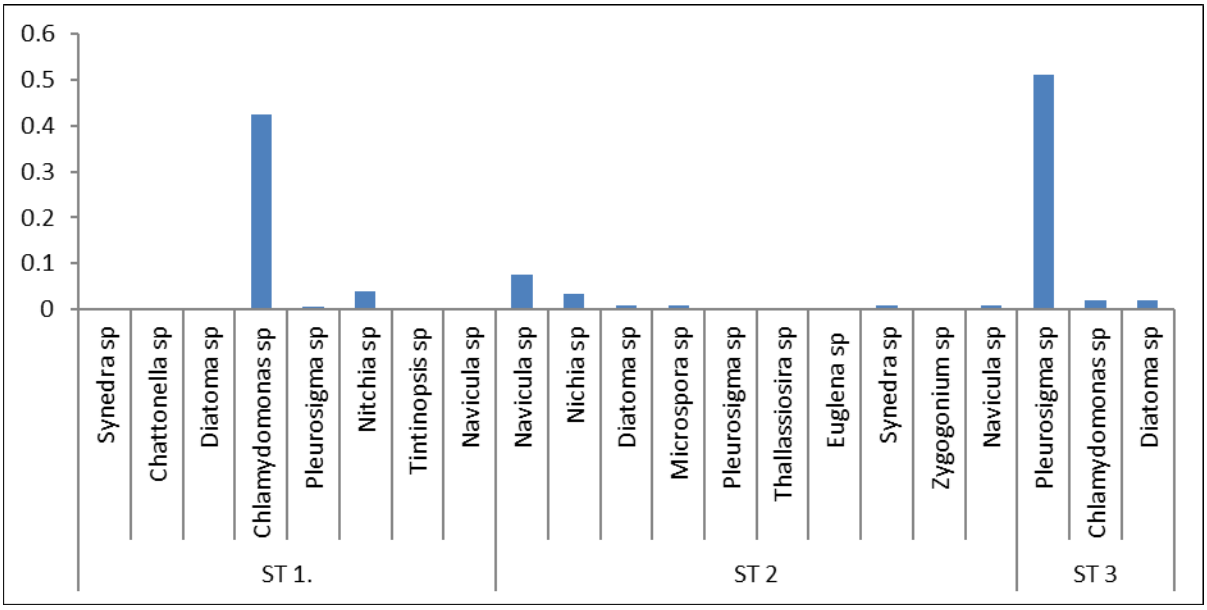

Figure 6 Plankton Dominance $(ni/N)^2 = pi^2$) Research Location

4. Conclusion

This study shows the number and abundance of plankton that occurs with the *Chlamydomonas* sp. plankton type found in ST 1, which is a location located in the Tamarupa River Estuary. The diversity of plankton is quite evenly distributed in all research locations, and the diversity in ST 1 is *Nitzschia* sp. plankton type, in ST 2 it is *Navicula* sp., and in ST 3 it is *Chlamydomonas* sp. and *Diatoma* sp. plankton types. The highest plankton uniformity value of the research location is in ST 2, namely 0.151358456. Furthermore, the dominance value of the *Chlamydomonas* sp. plankton type is found in

ST 1, and the *Pleurosigma* sp. plankton type is found in ST 3. The research location is still suitable for milkfish cultivation, especially for cultivation with traditional systems.

Compliance with ethical standards

Disclosure of conflict of interest

In this study there is no conflict of interest between the authors or researchers or other related institutions.

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