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Biodiversity study of phytoplankton capable of producing omega-3 in the coastal area of Subang, Indonesia

Dewi Cahyani

*Corresponding author: Tadris Biology, Faculty of Tarbiyah and Keguruan Sciences, UIN Siber Syekh Nurjati Cirebon, Indonesia. E-mail address: dewichy@gmail.com

Khonsa

Bachelor of Pharmacy, STIKes YLPP Cirebon, Indonesia. E-mail address: khonsa@gmail.com

Abdul Aziz

Postgraduate Programme, UIN Siber Syekh Nurjati Cirebon, Indonesia. E-mail address: abdul_aziz@syekhnurjati.ac.id

Abstract

Objective

Omega-3 fatty acids are essential polyunsaturated fatty acids known for their numerous health benefits, containing cardiovascular protection, anti-inflammatory effects, and assist for neural development. These nutrients are predominantly found in marine organisms such as fish and shellfish. While, phytoplankton, as the primary producers at the base of the marine food web, are the original source of Omega-3 fatty acids in aquatic ecosystems. Investigating phytoplankton as a direct and sustainable source of Omega-3 offers promising potential for the biopharmaceutical and aquaculture industries. This investigation aimed to recognize and measure phytoplankton species with high Omega-3 content from the coastal waters of Subang, Indonesia, and to determine their potential application in aquaculture, particularly in fish feed production.

Materials and Methods

The research was conducted along the coastal region of Cilamaya Girang in the Blanakan District of Subang Regency. Water samples were collected from five observation stations and analyzed for phytoplankton diversity and abundance applying microscopy and the Sedgwick-Rafter Counting Cell method. Chlorophyll-a concentration was measured via spectrophotometry to estimate phytoplankton biomass. Species identification was conducted to determine the phytoplankton composition, and the Shannon-Wiener diversity index was utilized to determine species diversity. Selected phytoplankton species were further analyzed for their Omega-3 fatty acid content to measure their suitability for aquaculture applications.

Results

Phytoplankton in the investigation area were classified into three major taxonomic groups: Cyanophyta, Bacillariophyta, and Dinophyta. The Shannon-Wiener diversity index values ranged from 0.07 to 0.16, indicating relatively low species diversity across the sampled sites. Identified genera included *Asterionella*, *Rhizosolenia*, *Skeletonema*, *Nitzschia*, *Pleurosigma*, *Coscinodiscus*, *Chaetoceros*, and *Bacteriastrum*, with the Bacillariophyta (diatoms) emerging as the dominant group. Among these, *Skeletonema* sp. was the most abundant per cubic meter of seawater. While, *Chaetoceros* sp., another member of Bacillariophyta, exhibited the highest Omega-3 content, highlighting its potential as a precious source of Omega-3 for aquaculture feed formulations.

Conclusion

The findings underscore the significance of *Chaetoceros* sp. as a potent contributor to Omega-3 synthesis and its promise as a sustainable ingredient in aquaculture nutrition. The dominant presence of Bacillariophyta and the nutritional potential of specific diatom species suggest that targeted cultivation of such phytoplankton could assist environmentally friendly fish farming practices. Further research into the large-scale cultivation and incorporation of these microalgae into aquaculture systems could enhance the sustainability and efficiency of fish feed production.

Keywords: Aquaculture feed, phytoplankton diversity, diatoms, subang coastal waters, marine biotechnology

Paper Type: Research Paper.

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Introduction

Indonesia is a country endowed with vast marine potential, assisted by an abundance of diverse marine biota. This richness supplies numerous opportunities across various industrial sectors, one of which is the biotechnology industry, particularly in the realm of biopharmaceuticals. Despite its enormous potential, marine biodiversity remains underutilized, especially within biotechnology and biopharmaceutical development. One of the primary obstacles is the limited investigation and development on marine microorganisms, containing phytoplankton, which hold great promise as sources of bioactive compounds—particularly omega-3 fatty acids. Currently, fish are the main source of omega-3, raising issues related to overfishing, environmental sustainability, and fluctuations in supply. This project seeks to address these challenges by investigating phytoplankton as an alternative and more sustainable source of omega-3 in the coastal waters of Subang—an area whose marine resources have not yet been fully explored for biopharmaceutical applications. In recent pharmaceutical industry developments, drug production is no longer solely based on synthetic chemical compounds but has increasingly begun to incorporate biodiversity. Marine resources, which have long been utilized for fish-based protein (Purnomo & Syifara, 2022), also present meaningful opportunities as sources of pharmaceutical raw materials, as suggested by Herawati (2019). One of the most promising marine organisms for the biopharmaceutical sector is phytoplankton, which play a fundamental task as primary producers in the marine ecosystem. Phytoplankton are single-celled (unicellular) organisms that are microscopic in size, generally ranging from 0.002 to 0.2 mm. As autotrophs, they are crucial in determining the ocean’s primary productivity due to their ability to photosynthesize. Through this process, phytoplankton convert inorganic substances into organic matter, serving as the primary energy source for other organisms in the marine food chain (Aryawati & Thoha, 2011). Furthermore, the presence of phytoplankton in aquatic ecosystems can serve as an indicator of fish abundance. Higher phytoplankton populations indicate greater food availability for fish, potentially leading to increased fish catches (Sireger et al., 2013). The high nutritional content of phytoplankton further underscores their ecological importance. They are known to produce various essential nutrients such as omega-3, omega-6, and omega-9 unsaturated fatty acids, along with fiber, vitamins, protein, and minerals (Herawati, 2019). This nutritional richness enables phytoplankton to assist the survival of other marine organisms. Additionally, their dense nutrient profile makes them a potential food source that could be more broadly utilized in the health and pharmaceutical industries. This investigation specifically focuses on the omega-3 content of phytoplankton. Compared to other animal- and plant-based food sources, phytoplankton generally contain higher concentrations of omega-3. This gives them a unique advantage, as omega-3 is an essential nutrient required by the human body. With this strength, phytoplankton have great potential to be developed for utilize in the biopharmaceutical industry, particularly in producing marine-based health supplements. Omega-3 is a bioactive compound that plays a crucial task in assisting human health, growth, and development (Ngginak et al., 2013). It contains eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are important for maintaining overall physiological function. Due to its well-established health benefits, omega-3 is widely utilized as a dietary supplement to enhance the intake of essential fatty acids (Yulianto et al., 2022). Additionally, omega-3 possesses anti-inflammatory and anti-arrhythmic properties that benefit cardiovascular health. Regular consumption of omega-3 helps maintain heart function and decline the risk of cardiovascular diseases (Ngginak et al., 2013). Given its broad therapeutic potential, applying phytoplankton as a natural source of omega-3 presents an innovative solution for the health industry and could decline dependency on fish- or plant-based omega-3 sources. Subang is one of the regencies in Indonesia with vast marine potential. Its coastal areas include districts with notable fishery activity, such as Blanakan, Sukasari, Legon Kulon, and Pusakanegara. With a coastal zone spanning 333.57 km^2 (Diperbarui, 2013), this region offers marine resources that could be developed further-containing the utilize of phytoplankton as an omega-3 source. This investigation focuses on the Blanakan District, specifically Cimalaya Girang Village, which is located on the northern coast of Subang Regency. The majority of residents in this village work as fishermen, and Cimalaya Girang is known as the largest fish-producing region in the Subang area (Hanidah et al., 2018). Moreover, the area hosts numerous fish and shrimp farms, making it an ideal site for investigating phytoplankton with high omega-3 content. These aquaculture activities result in nutrient-rich waters, which are beneficial for phytoplankton productivity (Lyu et al., 2021). Nutrient-rich environments enhance the growth, diversity, and abundance of phytoplankton species—potentially making this area more promising than others for the discovery of high omega-3-producing species. This condition offers an opportunity to explore phytoplankton not only as ecological contributors but also as nutritional and pharmaceutical resources. Therefore, this investigation aims to recognize phytoplankton species with high omega-3 content that can be developed in the biopharmaceutical sector. Phytoplankton are known to be rich in essential fatty acids, and their potential is still underexplored in many regions (Cunha et al., 2019). By focusing on local phytoplankton species, this investigation introduces a new perspective in marine resource exploration, emphasizing their task in omega-3-based health supplement production. Given the growing global demand for natural omega-3 sources, this investigation is expected to offer precious insights into the potential of phytoplankton as sustainable producers of essential fatty acids. The outcomes may assist further phytoplankton-based product development and help decline dependence on conventional

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omega-3 sources derived from fish or plants. In doing so, the investigation may drive innovation within the biopharmaceutical industry and contribute to more sustainable marine biodiversity utilization. The novelty of this investigation lies in its exploration of phytoplankton from the coastal waters of Subang—a region that has not been extensively investigated. By recognizing high omega-3-producing phytoplankton species, this investigation opens new opportunities for efficient and sustainable marine-based resource utilize within the biopharmaceutical industry. Furthermore, the findings may contribute to broader discussions about the task of marine microorganisms in assisting human health and nutrition. Beyond health benefits, the biopharmaceutical utilize of phytoplankton could create economic value for coastal communities. If species with high omega-3 content can be cultivated and optimized, local populations-especially fishermen and aquaculture farmers-could benefit economically. This aligns with sustainable marine resource management principles that aim to balance ecological sustainability with community welfare. In this context, genetic diversity becomes essential. It facilitates the development of improved traits, assists population resilience, drives evolutionary progress, and enables adaptation to environmental changes (Javanmard et al., 2008; Mohammadabadi et al., 2021). Higher levels of genetic diversity enhance a population's ability to resist diseases, adapt to environmental stressors, and withstand selective pressures (Frankham et al., 2010). This diversity is fundamental not only for long-term species survival but also for sustainability in both natural and managed ecosystems. Moreover, recognizing genetic diversity is critical in detecting diseases, producing essential nutrients, and understanding relationships between traits and biological processes (Mohammadabadi & Tohidinejad, 2017; Saadatabadi et al., 2023). Genetic diversity also correlates directly with immune system effectiveness and resistance to infection. Insights into genetic variation inform selective breeding strategies to enhance growth, disease resistance, and nutritional quality in aquaculture and agriculture (Gjedrem & Rye, 2018). Additionally, the investigation and characterization of different populations applying modern techniques are essential for accurately determining and preserving genetic resources (Mohammadifar & Mohammadabadi, 2017; Noori et al., 2017; Jafari Ahmadabadi et al., 2023). Advances in molecular genetics and biotechnology have enabled the identification of advantageous traits and the implementation of targeted breeding strategies (Zhang et al., 2020). These strategies also assist conservation efforts by recognizing and preserving genetically precious or endangered populations. The conservation of biodiversity requires well-implemented management plans based on thorough knowledge of population structures, containing genetic resources within and among populations and breeds (Zamani et al., 2011; Molaei Moghbeli et al., 2013). As emphasized by McMahon et al. (2014), conservation is fundamental for ensuring biodiversity for future generations, as well as for maintaining food security and ecological balance. Sustaining genetic diversity contributes to developing beneficial traits such as increased productivity, stress resilience, and environmental adaptability (Askari et al., 2011; Mohammadabadi et al., 2024). Finally, the identification of genetic variation is not only critical for characterizing different populations (Mohammadabadi et al., 2010) but also for understanding individual traits and their impact on essential biological functions-such as immune responses, reproduction, production, and disease susceptibility or resistance (Norouzy et al., 2005; Shokri et al., 2023). By combining modern biotechnology with conservation genetics, we can enhance sustainability in industrial and natural systems and ensure the availability of genetic resources for utilize in environmental management, agriculture, and medicine. Thus, this investigation contributes not only to scientific advancements but also to the economic well-being of coastal populations by promoting phytoplankton as a precious and sustainable marine resource.

Materials and methods

Research area: Fieldwork was conducted in the coastal region of Cilamaya Girang, Subang Regency, Indonesia. This location was selected due to its high concentration of aquaculture ponds, making it a representative area for coastal pond systems. The investigation area is illustrated in Figures 1 and 2.

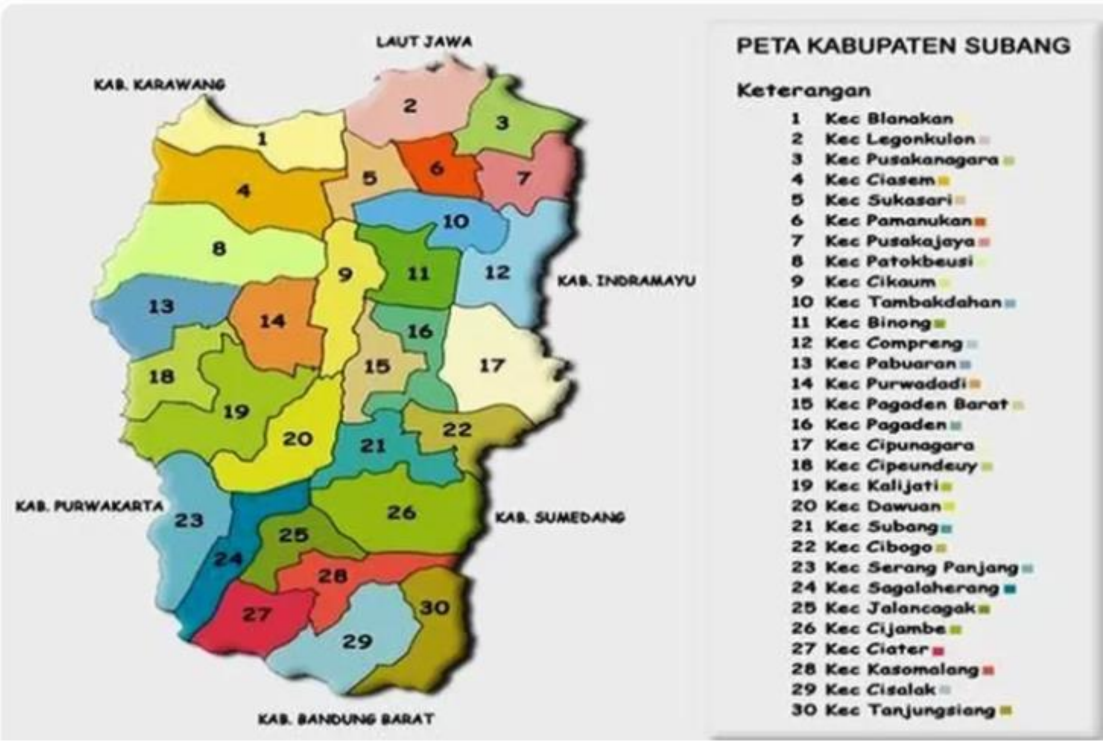

Figure 1. Map of the Cilamaya Girang region

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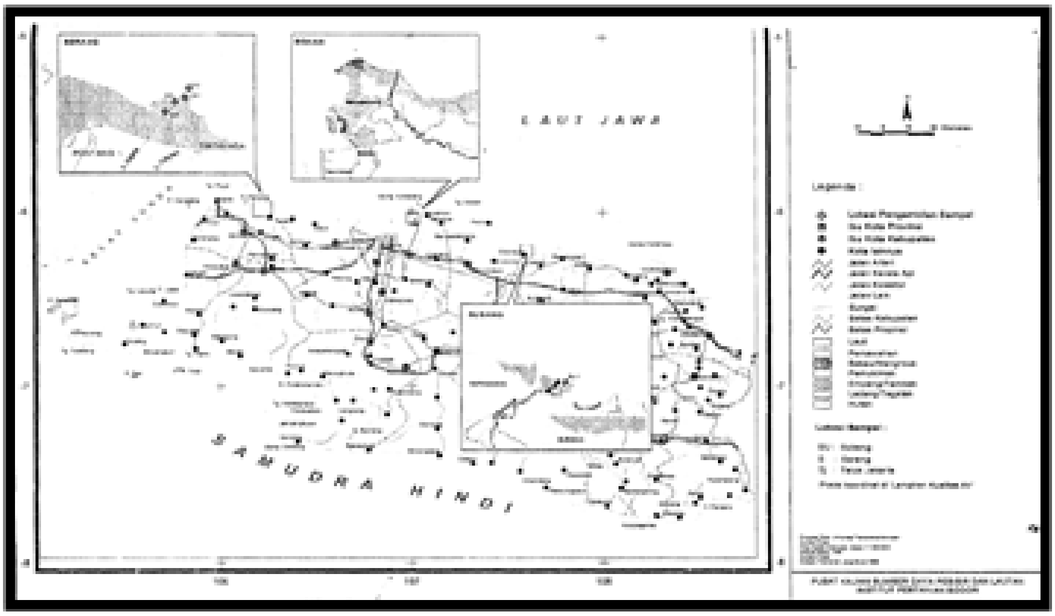

Figure 2. Coastal area of Cilamaya Girang

Data collection: Laboratory activities were conducted on water samples collected from five locations within the coastal area of Cilamaya Girang. Phytoplankton samples were obtained applying Van Dorn water samplers to ensure precise sampling at designated depths. From each sampling point, 30 liters of water were collected. A portion of each sample was preserved with Lugol's solution or formalin for microscopic identification. Phytoplankton species were identified under a microscope applying a standard taxonomic identification guide. Plankton enumeration was carried out applying a Sedgwick-Rafter counting cell (Lantang & Pakidi, 2015). Additionally, phytoplankton biomass, expressed as chlorophyll-*a* concentration, was measured applying a spectrophotometer. A literature review was also conducted to determine which phytoplankton species are known to contain omega-3 fatty acids.

Data analysis: Phytoplankton diversity was analyzed applying the Lackey Drop Microtransect Counting Method (Leica, Germany), and the data were processed applying standard equations as described by APHA (2005).

Dominance index: The dominance index was calculated applying Simpson's Dominance Index formula:

$$D = \sum_{i=1}^{s} (\frac{n_i}{N})^2$$

Where:

D = Simpson's dominance index, n_i = Number of individuals of the i-th species, N = Total number of individuals, S = Total number of species (genera)

Diversity index: Phytoplankton diversity was determined applying the Shannon-Wiener Diversity Index (Michael, 1994, as cited in Kooistra et al., 2008):

$$H' = -\sum_{i=1}^{s} \left(\frac{ni}{N}\right) \ln\left(\frac{ni}{N}\right)$$

Where:

H' = Shannon-Wiener diversity index, n_i = Number of individuals of the i-th species, N = Total number of individuals, S = Total number of species (genera)

Evenness Index: Species evenness was calculated applying the following equation (Michael, 1994, as cited in Kooistra et al., 2008):

$$E = \frac{H'}{\ln(S)}$$

Where:

E = Evenness index, H' = Shannon-Wiener diversity index, S = Total number of species (genera)

The index E ranges from 0 to 1, where:

E = 0 indicates low evenness, i.e., a highly uneven distribution of individuals among species, E = 1 indicates complete evenness, i.e., individuals are distributed uniformly among species.

Results and discussion

The Cimalaya Girang coastal area in Subang Regency is recognized as a productive pond region with abundant fishery resources. This area plays a critical task in the local economy, as many residents depend on fish and shrimp farming for their livelihoods. The richness of aquatic resources in this region makes it an ideal site for investigation on marine biodiversity, particularly phytoplankton and their nutritional composition. In this investigation, phytoplankton samples were collected from five distinct points along the Cimalaya Girang coastline. These sampling sites were strategically chosen based on environmental parameters such as water quality, proximity to aquaculture activities, and potential nutrient availability. By determining phytoplankton diversity across multiple locations, the investigation aimed to generate comprehensive data on the distribution and species composition of these microorganisms. The investigation specifically targeted phytoplankton species known for their high omega-3 fatty acid content, given the well-documented health benefits of these compounds. The collected samples underwent detailed analysis, and the findings were systematically recorded in accordance with established methodologies (Liu et al., 2022). The analysis yielded insights into the types of

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phytoplankton present and their potential applications in the biopharmaceutical industry. The results are summarized in Table 1, which presents key findings from each sampling site. The data include phytoplankton abundance, species diversity, and omega-3 fatty acid content. This structured presentation highlights site-specific differences and offers a clearer understanding of how environmental factors impact phytoplankton community dynamics. Overall, the findings of this investigation contribute precious insights into the potential of phytoplankton from the Cimalaya Girang coastal area as a natural source of omega-3 fatty acids. The results may assist future investigation on sustainable marine resource utilization and the development of marine-derived health supplements. Moreover, the investigation emphasizes the importance of conserving coastal ecosystems to maintain the availability of such precious marine resources.

Table 1. Phytoplankton species and their abundance (cells/mL) at five sampling stations (SU-1 to SU-5) in the coastal area of Cimalaya Girang, Subang Regency

Taxonomic Group / Species	SU-1	SU-2	SU-3	SU-4	SU-5
CYANOPHYCEAE					
Trichodesmium sp.	155,000	0	0	150,000	0
BACILLARIOPHYCEAE					
Coscinodiscus sp.	150,000	300,000	0	450,000	350,000
Chaetoceros sp.	2,040,000	1,250,000	0	6,400,000	3,400,000
Bacteriastrum sp.	0	450,000	0	0	0
Thalassiosira sp. *(corrected)*	0	300,000	0	350,000	0
Asterionella sp.	1,880,000	1,600,000	0	3,500,000	1,500,000
Rhizosolenia sp. *(corrected)*	300,000	350,000	0	300,000	150,000
Skeletonema sp.	224,800,000	495,500,000	0	238,800,000	201,000,000
Nitzschia sp.	2,450,000	1,300,000	0	0	2,000,000
Pleurosigma sp.	0	300,000	0	0	1,600,000
DINOPHYCEAE					
Protoperidinium sp.	2,460,000	1,350,000	0	0	1,800,000
Ceratium sp.	0	350,000	0	600,000	0
Peridinium sp.	2,600,000	3,700,000	0	1,080,000	150,000
Dinophysis sp. *(corrected)*	1,590,000	950,000	0	1,250,000	0
Prorocentrum sp.	300,000	0	0	0	0
Noctiluca sp.	140,000	0	0	300,000	150,000
Number of Taxa	12	13	0	11	10

Based on the data presented in Table 1, the phytoplankton species identified in the coastal waters of Cimalaya Girang belong to three major taxonomic classes: Cyanophyceae, Bacillariophyceae, and Dinophyceae. The presence of these diverse classes highlights the complexity of the phytoplankton community in this region and supplies precious insights into the local environmental conditions. Understanding the distribution and composition of these phytoplankton groups is essential for evaluating the ecological status of the area and its potential for sustainable marine resource utilization. Among the three classes, Bacillariophyceae was the most dominant in terms of both species richness and abundance across all sampling stations. Notably, *Skeletonema* sp. emerged as the most abundant species at each location, indicating its strong adaptability and ecological competitiveness in the coastal ecosystem. Figures 3, 4, and 5 further illustrate key community structure metrics: the phytoplankton diversity index, uniformity index, and dominance index, respectively. These indices assist the quantitative determining of species distribution and ecological balance within the investigated area.

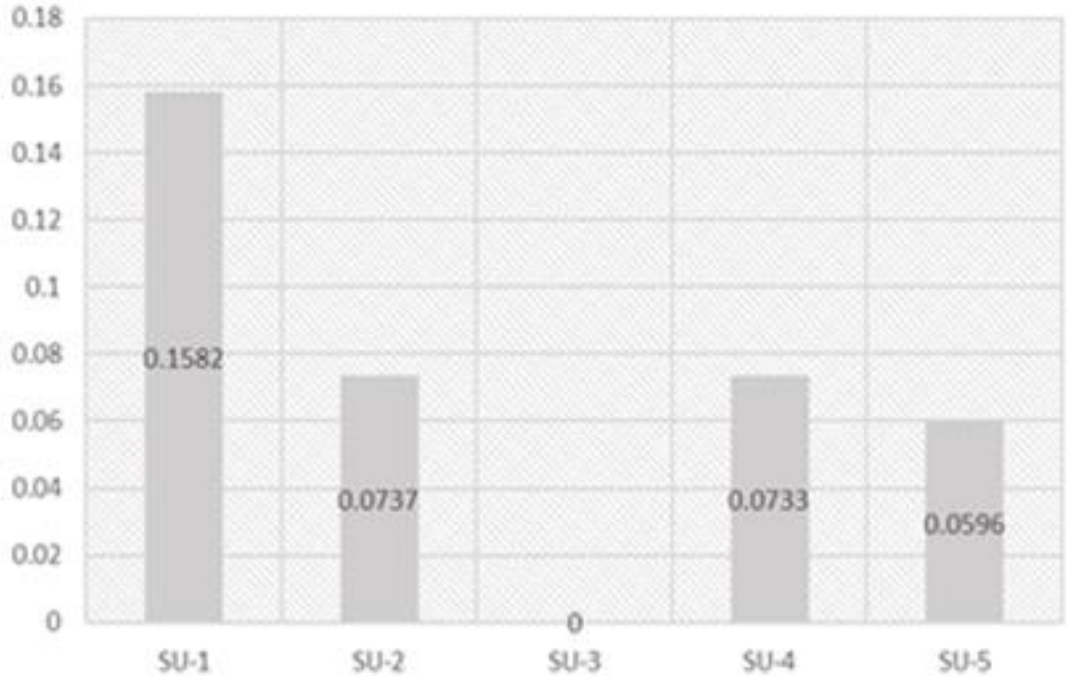

Figure 3. Phytoplankton diversity index at five sampling stations (SU-1 to SU-5) in the coastal area of Cimalaya Girang, Subang Regency. The index reflects species richness and evenness, providing an overview of phytoplankton community complexity

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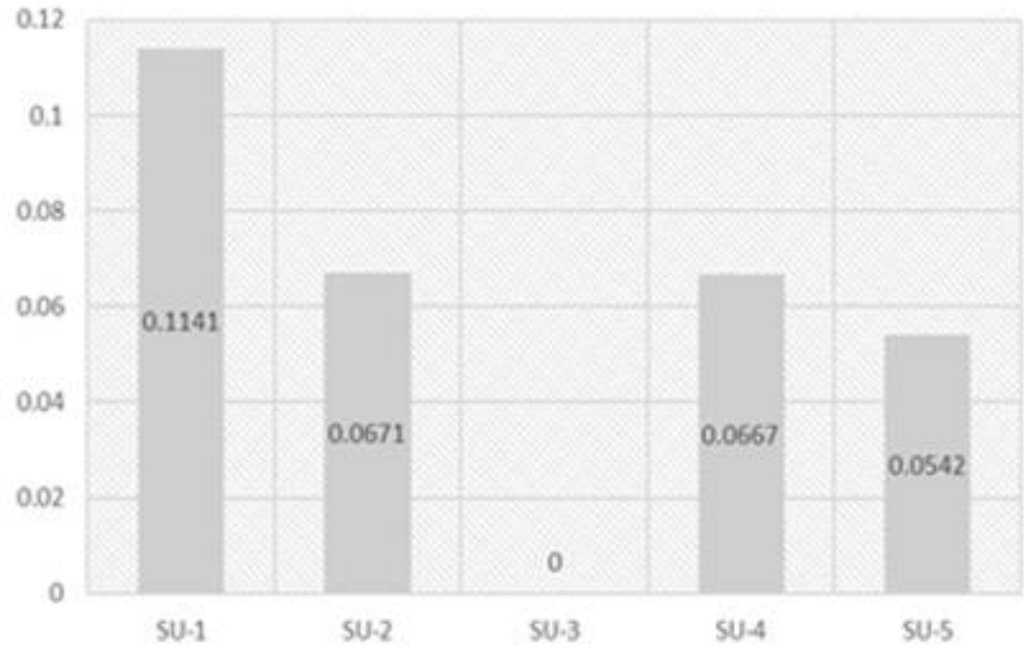

Figure 4. Phytoplankton uniformity (evenness) index across the five sampling stations. This index indicates how evenly individuals are distributed among the identified species at each site

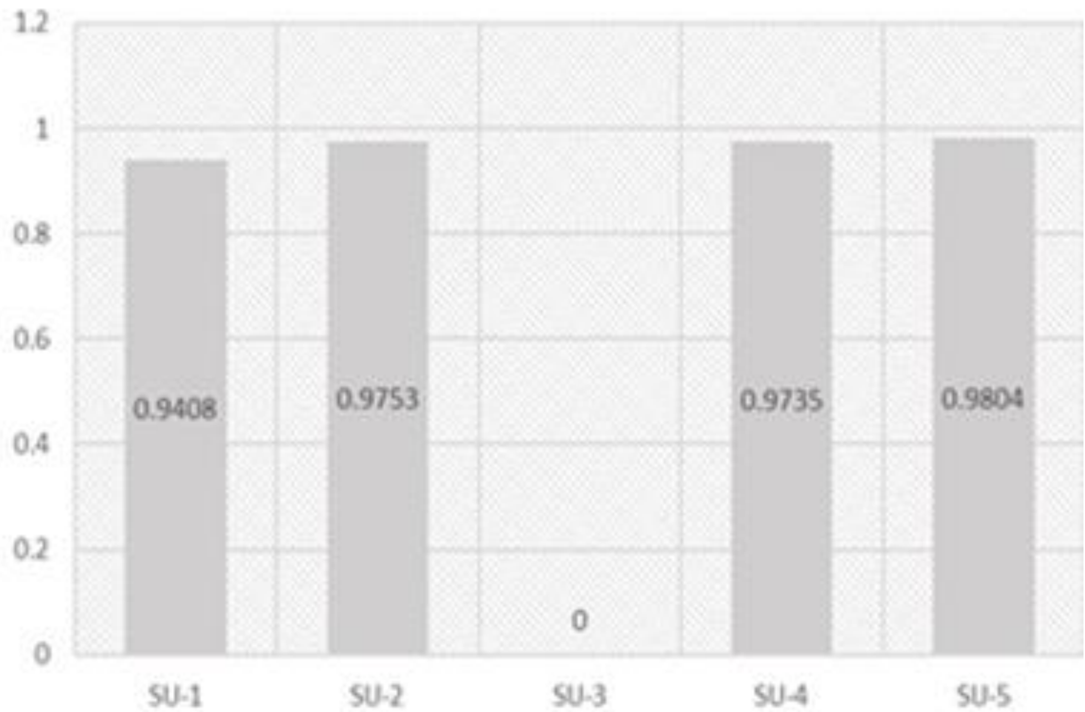

Figure 5. Phytoplankton dominance index for each sampling station, showing the degree to which a single or few species dominate the phytoplankton community

Microalgae, particularly phytoplankton, are capable of producing energy and bioactive compounds. According to Sugianti et al. (2015), microalgae exhibit higher efficiency in utilizing solar energy compared to higher terrestrial plants. Due to this efficiency, phytoplankton are considered a promising biological resource for various industries, containing renewable energy and pharmaceuticals. Additionally, phytoplankton offer pharmacological benefits such as antibacterial, antioxidant, anti-inflammatory, anticancer, and hepatoprotective effects. These benefits underscore the importance of phytoplankton not only for aquatic ecosystems but also for biomedical applications. While, despite their advantages, certain phytoplankton species—particularly from the phyla Dinoflagellata and Cyanobacteria—pose serious risks when they proliferate excessively and form harmful algal blooms (HABs). Dinoflagellates such as *Alexandrium spp.*, *Karenia brevis*, and *Gonyaulax spp.* produce neurotoxins like saxitoxins, brevetoxins, and ciguatoxins. These compounds bioaccumulate in marine organisms and can cause severe health issues in humans, such as paralytic shellfish poisoning (PSP) and neurotoxic shellfish poisoning (NSP). Similarly, cyanobacteria such as *Microcystis spp.*, *Anabaena spp.*, and *Nodularia spp.* release toxins like anatoxins, cylindrospermopsins, and microcystins, which can result in neurological, respiratory, and hepatic impairments in both aquatic organisms and humans. Eutrophication—particularly in nutrient-rich, warm waters impacted by urban runoff and agricultural discharges—often exacerbates HAB events, posing environmental, economic, and public health challenges. These concerns highlight the importance of ongoing monitoring and sustainable phytoplankton management. Among the phytoplankton identified, the Bacillariophyceae (diatoms) class is especially precious due to its high content of essential fatty acids such as myristic acid, palmitoleic acid, DHA, and EPA (Herawati, 2019). These compounds enhance the nutritional value of diatoms within aquatic food webs and present opportunities for application in the food and health sectors. In the coastal waters of Cimalaya Girang, the diversity of phytoplankton species, particularly Bacillariophyceae, indicates meaningful biopharmaceutical potential. Harnessing this biodiversity could facilitate the discovery and development of high-value natural compounds. Further exploration and investigation are essential to fully determine the potential of microalgae in this region. According to Figure 3, Station SU-1 exhibited the highest phytoplankton diversity index, while Station SU-5 showed the lowest. This suggests that SU-1 offers more favorable environmental conditions—such as better water quality, nutrient balance, and ecological stability-that assist a more diverse phytoplankton community. Conversely, the lower diversity at SU-5 may reflect environmental stressors or imbalanced conditions that hinder species richness. These observations are assisted by Figure 4, which shows that SU-1 also had the highest uniformity index, indicating a more even distribution of phytoplankton species without dominance by a single taxon. Such balance suggests a stable and healthy ecosystem. In contrast, SU-5 exhibited the lowest uniformity, pointing to an uneven distribution potentially driven by ecological stressors, such as pollution or nutrient imbalances, that allow certain species to outcompete others. Figure 5 illustrates the phytoplankton dominance index, showing that SU-5 had the highest value, indicating the presence of dominant species—possibly due to eutrophication or specific environmental pressures. SU-1, on the other hand, recorded the lowest dominance, reinforcing the conclusion that it represents a more balanced and less stressed ecosystem. These interstation differences emphasize how varying environmental conditions-such as nutrient availability, aquaculture activities, and pollution can meaningfully impact phytoplankton community structure. The greater diversity and uniformity at SU-1 suggest a more sustainable environment, while SU-5's higher dominance and lower diversity may signal ecological stress. The distribution patterns observed in Figures 3, 4, and 5 likely reflect both natural and anthropogenic impacts. Factors such as agricultural runoff, aquaculture waste, and altered hydrodynamic conditions may play key tasks. Further investigation is needed to distinguish between these drivers and understand their specific impacts. Such insights would be invaluable for developing targeted and sustainable management strategies. Overall, the investigation underscores the importance of tracking phytoplankton diversity, uniformity, and dominance as indicators of ecological health. A stable phytoplankton community assists aquatic biodiversity and sustains marine-based human activities. Future investigation should aim to recognize specific environmental parameters that drive these patterns to ensure long-term ecosystem productivity and resilience. These findings align with Herawati (2019), who reported that *Chaetoceros sp.* contains the highest levels of omega-3 fatty acids. These fatty acids are crucial for the development of higher trophic-level organisms, making *Chaetoceros* a particularly precious phytoplankton species for the production of nutraceuticals. The chemical composition of microalgae, While, is not fixed—it varies based on environmental factors such as nutrient availability, temperature, light intensity, and growth conditions. For instance, *Chaetoceros sp.* has been shown to produce higher levels of unsaturated fatty acids in colder temperatures (Jati et al., 2012), illustrating how environmental control can be leveraged to enhance the biochemical output of microalgae.

Conclusions: This investigation supplies precious insights into the composition, spatial distribution, and potential applications of phytoplankton communities in the coastal waters of Cimalaya Girang, Subang Regency. The results identified three dominant classes—Cyanophyceae, Bacillariophyceae, and Dinophyceae—with Bacillariophyceae, especially *Skeletonema sp.*, being the most abundant across sampling stations. Notably, the presence of *Chaetoceros sp.*, known for its high omega-3 content, highlights the potential of this region as a source of bioactive compounds for the pharmaceutical and nutraceutical industries. Environmental factors such as water quality, nutrient loading from aquaculture, and anthropogenic inputs appear to meaningfully impact phytoplankton diversity and abundance. The contrast between Station SU-1 (high diversity and low dominance) and Station SU-5 (low diversity and high dominance) suggests spatial heterogeneity in ecological conditions, with potential implications for ecosystem health and resilience. These findings affirm the central task of phytoplankton in marine ecosystems and their promise as a renewable resource for industrial applications. Understanding the factors that shape phytoplankton community structure is essential for the development of sustainable management strategies. Long-term monitoring, coupled with targeted studies on the environmental determinants of phytoplankton productivity, will be critical for maximizing the ecological and economic benefits of these microorganisms. The coastal region of Cimalaya Girang presents a compelling case for integrating biodiversity conservation with biopharmaceutical innovation.

Author Contributions

Conceptualization: Dewi Cahyani, Khonsa, and Abdul Aziz; Methodology: Dewi Cahyani; Software: Abdul Aziz; Validation: Dewi Cahyani, Khonsa, and Abdul Aziz; Formal Analysis: Khonsa; Investigation: Dewi Cahyani; Resources: Abdul Aziz; Data Curation: Dewi Cahyani; Writing—Original Draft Preparation: Dewi Cahyani; Writing—Review and Editing: Khonsa and Abdul Aziz; Visualization: Dewi Cahyani; Supervision: Abdul Aziz; Project Administration: Abdul Aziz. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data assisting the findings of this investigation are available from the corresponding author upon reasonable request. Due to privacy or ethical considerations, some datasets may not be publicly accessible. Supplementary data may be supplied upon request.

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Ethical Considerations

The authors affirm that all investigation practices complied with ethical standards. No instances of data fabrication, falsification, plagiarism, or misconduct occurred throughout the investigation process.

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Conflict of Interest

The authors declare no conflicts of interest. The funders had no task in the design of the investigation; in the collection, analysis, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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انجمن بیوتکنولوژی ایران
مجله بیوتکنولوژی کشاورزی
دانشگاه شهید باهنر کرمان
شاپا چاپی: ۶۷۰۵-۲۲۲۸ شاپا الکترونیکی: ۶۵۰۰-۲۲۲۸

مطالعه تنوع زیستی فیتوپلانکتون‌های تولیدکننده امگا-۳ در ناحیه ساحلی سوبانگ، اندونزی

دوی چاهیانی

*نویسنده مسئول: گروه آموزش زیست‌شناسی، دانشکده تربیت و علوم تربیتی، دانشگاه IAIN شیخ نورجاتی چیربون، اندونزی.

ایمیل: dewichy@gmail.com

خونسا

کارشناسی داروسازی، مدرسه عالی علوم سلامت YLPP چیربون، اندونزی. ایمیل: khonsa@gmail.com

عبدل عزیز

برنامه تحصیلات تکمیلی، دانشگاه IAIN شیخ نورجاتی چیربون، اندونزی. ایمیل: abdul_aziz@syekhnurjati.ac.id

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چکیده

هدف: اسیدهای چرب امگا-۳، اسیدهای چرب غیراشباع ضروری هستند که به دلیل فواید بی‌شمار برای سلامتی، از جمله محافظت قلبی‌عروقی، اثرات ضدالتهابی و حمایت از رشد سیستم عصبی شناخته شده‌اند. این مواد مغذی عمدتاً در موجودات دریایی مانند ماهی و صدف یافت می‌شوند. با این حال، فیتوپلانکتون‌ها به عنوان تولیدکنندگان اولیه در زنجیره غذایی دریایی، منبع اصلی اسیدهای چرب امگا-۳ در اکوسیستم‌های آبی محسوب می‌شوند. بررسی فیتوپلانکتون‌ها به عنوان منبع مستقیم و پایدار امگا-۳، پتانسیل امیدبخشی را برای صنایع بیوفارما و آبزی‌پروری فراهم می‌کند. هدف این مطالعه شناسایی و ارزیابی گونه‌های فیتوپلانکتونی با محتوای بالای امگا-۳ در آب‌های ساحلی سوبانگ، اندونزی و بررسی کاربرد احتمالی آن‌ها در آبزی‌پروری، به‌ویژه در تولید غذای ماهی بود.

مواد و روش‌ها: این پژوهش در ناحیه ساحلی چیلامایا گیرانگ، منطقه بلاناکان در شهرستان سوبانگ انجام شد. نمونه‌های آب از پنج ایستگاه مشاهده، جمع‌آوری و از نظر تنوع و فراوانی فیتوپلانکتون با استفاده از میکروسکوپ و روش شمارش سلولی سدگویک-رافترِ تحلیل شدند. غلظت کلروفیل a به‌وسیله اسپکتروفتومتر برای برآورد زیست‌توده فیتوپلانکتونی اندازه‌گیری شد. شناسایی گونه‌ها برای تعیین ترکیب فیتوپلانکتون انجام شد و از شاخص تنوع شانون-وینر برای ارزیابی تنوع گونه‌ای استفاده گردید. گونه‌های منتخب

فیتوپلانکتون به‌طور جداگانه از نظر میزان اسیدهای چرب امگا-۳ تحلیل شدند تا مناسب بودن آن‌ها برای کاربرد در آبزی‌پروری بررسی شود.

نتایج: فیتوپلانکتون‌های ناحیه مورد مطالعه به سه گروه اصلی تاکسونومیک تقسیم شدند: سیانوفیتا، باسیلاریوفیتا و دینوفیتا. مقدار شاخص تنوع شانون-وینر در محدوده ۰.۰۷ تا ۰.۱۶ قرار داشت که نشان‌دهنده تنوع نسبتاً پایین گونه‌ها در ایستگاه‌های نمونه‌برداری بود. جنس‌های شناسایی‌شده شامل *Chaetoceros*، *Coscinodiscus*، *Pleurosigma*، *Nitzschia*، *Skeletonema*، *Rhizosolenia*، *Asterionella* و *Bacteriastrum* بودند که در این میان، دیاتوم‌ها (Bacillariophyta) گروه غالب را تشکیل دادند. در بین آن‌ها، *Skeletonema sp.* بیشترین فراوانی را در هر متر مکعب آب دریا داشت. با این حال، *Chaetoceros sp.* که دیگر عضو گروه باسیلاریوفیتا است، بالاترین میزان امگا-۳ را نشان داد و این موضوع پتانسیل بالای آن را به‌عنوان منبعی ارزشمند از امگا-۳ برای تهیه غذای آبزیان برجسته می‌سازد.

نتیجه‌گیری: یافته‌ها بر اهمیت *Chaetoceros sp.* به‌عنوان یک تولیدکننده قوی امگا-۳ و قابلیت آن به‌عنوان یک ماده اولیه پایدار در تغذیه آبزیان تأکید دارند. حضور غالب باسیلاریوفیتا و پتانسیل تغذیه‌ای برخی گونه‌های دیاتومی نشان می‌دهد که پرورش هدفمند این فیتوپلانکتون‌ها می‌تواند به توسعه روش‌های پایدار و سازگار با محیط زیست در آبزی‌پروری کمک کند. تحقیقات بیشتر در زمینه پرورش در مقیاس بزرگ و ادغام این میکروجلبک‌ها در سیستم‌های پرورش آبزیان، می‌تواند پایداری و کارایی تولید غذای ماهی را بهبود بخشد.

کلمات کلیدی: آب‌های ساحلی سوبانگ، تنوع فیتوپلانکتون، دیاتوم‌ها، زیست‌فناوری دریایی، غذای آبزیان

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