The role of salinity and Total Suspended Solids (TSS) to abundance and structure of phytoplankton communities in estuary Saddang Pinrang

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The role of salinity and Total Suspended Solids (TSS) to abundance and structure of phytoplankton communities in estuary Saddang Pinrang

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Abstract. Phytoplankton is organisms that have a sensitivity to changes in the characteristics of the waters. Some determining factors of its existence are salinity, total suspended solids (TSS), and other compounds. Research has been conducted on the role of salinity and TSS in the abundance and structure of phytoplankton communities in the estuary of Saddang River Pinrang Regency. Research implementation in September to December 2020. The result of phytoplankton enumeration is found 25 Genera in 4 classes namely Bacillariophyceae, Chlorophyceae, Cyanophyceae, and Dinophyceae. Salinity has a real effect and shows a negative relationship to phytoplankton abundance. In contrast, TSS showed no real link to the abundance of phytoplankton in the estuary waters of Saddang Pinrang.

1. Introduction

Phytoplankton is one of the microorganisms that are sensitive to changes in aquatic characteristics [1,2]. Therefore, the microorganism is often used as an ecological indicator of water [3–6]. Just like terrestrial beings, phytoplankton also requires optimal environmental conditions to grow and develop [7,8]. Salinity and total suspended solids (TSS) are two factors of many environmental factors determining their existence in the waters [9].

Salinity is one of the aquatic parameters affecting phytoplankton life [10,11]). Salinity variation affects the rate of photosynthesis especially in estuary areas, particularly in phytoplankton that can only survive within small salinity boundaries (stenohaline) [12]. Simanjuntak in 2009 reported that the relationship between phytoplankton and salinity is significant ($p<0.05$) and correlates strongly and positively (0.685) [13].

TSS is associated with the presence of particles in the water column. This can limit sunlight entering the body of water [14]. Observation of this factor needs to be made because it affects the primary productivity of phytoplankton [15,16]. According to Sew and Todd in 2020, TSS has an association with phytoplankton. Its abundance is found quite high in locations with low TSS levels [17].

Saddang Estuary is one of the territorial waters that is thought to have different characteristics than other estuaries. This water empties into the northern part of Pinrang Regency, getting water input from the Makassar strait and Saddang river [18]. The mixing of the two water causes the physical and chemical parameters to fluctuate, thus affecting the existence of organisms.

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Like for example phytoplankton, not all of its kind can live with such aquatic conditions. The amount of pressure from human activity around Saddang estuary is also one of the factors that influence changes in community structure and abundance. The influx of freshwater originating from the Saddang River causes the physical and chemical parameters of estuary waters such as salinity and TSS to fluctuate further. This condition can affect the survival of phytoplankton which have an important role in the food chain in the waters.

Research on the role of salinity and TSS on community structure and phytoplankton abundance in the Saddang Estuary has never been conducted. Therefore, research has been conducted concerning it. The results of this study are expected to be basic data and references in the implementation of other studies on the depiction of oceanographic conditions, especially salinity and TSS as well as the presence of phytoplankton species, with a broader study of these waters.

2. Methods

This research was conducted from September to December 2020, located in the estuary waters of Saddang Pinrang Regency. There are three observation stations (Figure 1) namely Station I is at the mouth of the inner river, Station II is right at the mouth of the river, and Station III is off the coast. At each station, water sampling is performed for phytoplankton identification and measurement of nitrate, phosphate, pH, TSS, and salinity concentrations. Identification and analysis of samples were conducted in the laboratory of Chemical Oceanography Department of Marine Sciences Faculty of Marine Science and Fisheries Unhas. Measurements of chemical physics parameters such as temperature, brightness, and current are also performed at each station.

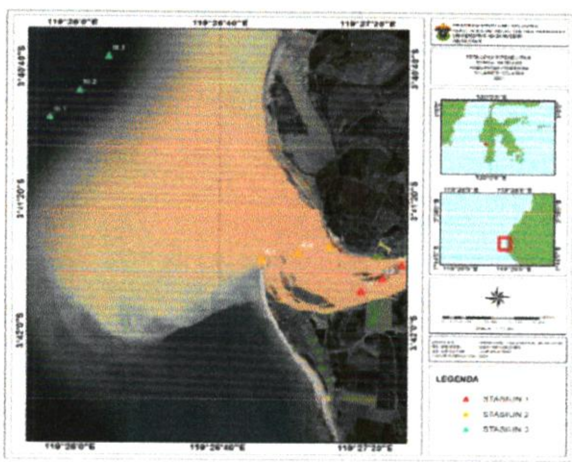

Figure 1. Research Location.

One-way ANOVA variance analysis is used to determine the abundance of plankton between stations. Correlation analysis is used to determine the effect of salinity and total suspended solids (TSS) on phytoplankton abundance. For analysis of phytoplankton community structure using the ecological index.

3. Results and discussion

3.1. Measurement of Oceanographic Parameter

The measurement results of oceanographic parameters at each station such as the average temperature obtained ranged from 27.6-28.2 °C, the average pH ranged from 7.69- 7.74, and the measured average salinity ranged from 1.9-30 a.m. Furthermore, the average water brightness ranges from 58.33-625 cm,

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and the average current speed obtained ranges from 0.05-0.20 m/s. For measurement of total suspended solids (TSS) content on average ranges from 73.9-113.9 Mg/l. In general, the measurement results of oceanographic parameters are in the range of values that support phytoplankton growth.

Temperatures in the waters have a direct or indirect role in the activity of organisms [19,20]. The influence of temperature can directly affect the rate of photosynthesis of plants and the physiological processes of animals, and will indirectly affect the degree of metabolism and its reproduction cycle. Temperatures in estuary waters vary more than in nearby coastal waters (Trombetta et al., 201). When freshwater enters the estuary and mixes with seawater, temperature changes occur. This large temperature variation occurs as a function of the difference between seawater temperature and river water [21].

The pH value describes the intensity of acidity and wetness of water indicated by the presence of hydrogen ions. Most aquatic organisms are sensitive to pH changes and like pH values around 7 - 8.5 [16]. Waters with a pH between 6 - 9 are waters with high fertility and are classified as productive because they have a pH range that can encourage the mineralization process of organic matter in the waters into minerals that can be assimilated by phytoplankton [22]. But according to Arinardi *et al.* in 1997, the pH change is less so affecting the environmental conditions of estuary waters [23].

The salinity of estuary waters is usually lower than the salinity of the surrounding waters [24]. At the mouth of the river, salinity varies greatly at the turn of the season i.e. the rainy season and the dry season [23]. Salinity distribution in the sea is influenced by various factors such as water circulation patterns, evaporation, rainfall, and river flow [25]. Waters with high rainfall levels and influenced by river flows have low salinity while waters that have high evaporation, high salinity of the water.

Brightness is a measure of water transparency, which is determined visually by using a Secchi disk expressed in meters. This value is strongly influenced by the measurement time, weather conditions, turbidity, and suspended solids, as well as the accuracy of the person taking the measurement [16].

Current is the transfer of water mass from one place to another, caused by various factors such as pressure gradients, wind gusts, density differences, or tides [26]. In most waters, the main factors that can cause relatively strong currents are wind and tides. Currents are a physical factor that has a lot of influence on the distribution and abundance of plankton in sea waters [27]. Currents are very influential on the spread of phytoplankton because their movement is highly dependent on the movement of water [28,29].

Suspended solids can affect the turbidity and brightness of the waters. Suspended solids are particles floating in the water, consisting of biotic and abiotic components [17]. Biotic components consist of zooplankton phytoplankton, bacteria, and fungi, while abiotic components consist of organic detritus derived from living bodies and inorganic particles. Suspended solids in water generally consist of plankton, mud, organism droppings, plant and animal remains, and industrial valley fibers. Waters with high suspended solids inhibit the rate of photosynthesis as a result of the inhibition of sunlight penetration into the waters [30].

Increased charge levels of suspended solids cause turbidity that can interfere with the penetration of light into the water. The presence of suspended sediment in the waters can affect water quality and aquatic organisms, either directly or indirectly such as death and decreased production. Particles suspended in the water mass can limit the primary productivity value of the water as a result of inhibition of light penetration into the body of water [31].

3.2. Measurement of Nutrients for Nitrate and Phosphate Types

During the study, the average measurable nitrate concentration ranged from 0.363-0.496 mg/l. The highest nitrate concentration was found at station II which was 0.496 mg/l, while the lowest nitrate concentration was at station I of 0.363 mg/l. The high nitrate levels at station II are thought to be caused by its location in the middle of the river estuary and is carried out at high tide which is suspected to be stirring (turbulence) of the base of a strong expansion so that nutrients and organic matter located at the bottom of the water are lifted to the surface layer. This is similar to Tambaru *et* *al.* in 2020 which states that the distribution of nitrate concentrations is getting higher towards the coast and the highest concentrations are found in the waters of the river estuary [3].

The high concentration of nitrate in station II is also thought to be due to the proximity of the observation site to the settlement which causes the number of additional nutrients derived from the domestic waste disposal of the community. The high nitrate content in the waters is also caused by various factors including the current that carries nitrates and the abundance of phytoplankton [29]. Nitrate levels in Saddang estuary waters, in general, are still by the common nitrate content in marine waters. Normal nitrate content in sea waters generally ranges from 0.00014-0.7 mg/l [32]. According to Wardoyo in 1982, the range of nitrate levels sufficient for the growth of the organism is 0.3-0.9 mg /l and >3.5 mg / l can harm the waters [33]. Mackenthum in 1969 states that phytoplankton optimal growth is in the nitrate range between 0.9-3.5 mg/l [34]. The range of nitrate concentrations in Saddang estuary waters is still within the safe limits of the fertility of water.

Nitrate concentration is one of the factors that affect the fertility of water. Nitrates are a source of nitrogen for plants that can be converted into proteins [35]. Nitrate compounds are the result of the oxidation of nitrogen entering the waters through the diffusion process [36]. Nitrates are the main form of nitrogen in natural waters and are the main nutrient for plant and algae growth. Nitrate levels in unpolluted waters are usually higher than ammonium levels. Nitrate-nitrogen levels in natural waters are rarely more than 0.1 mg/liter. Nitrate levels exceeding 0.2 mg/liter may result in water eutrophication [16]. Nitrogen is an important element for phytoplankton growth which is one of the main elements in protein formation. Nitrogen is a nutrient needed in the process of photosynthesis absorbed in the form of nitrates, then converted into a food source for fish.

As with nitrate nutrients, phosphates are also chemical compounds that serve as nutrients in the waters. High concentrations of nitrate and phosphate nutrients are one of the determining indicators of the fertility of water. Phosphate concentrations in Saddang estuary waters range from 0.019-0.027 mg/l. The highest nitrate concentration obtained at the station I was 0.027 mg/l. The lowest nitrate concentration in station III was 0.019 mg/l. High levels of phosphate in the waters at station I and station II are thought to be caused by the large supply of nutrients that enter the waters from the waste of inorganic waste and also the number of nutrients carried by river currents and accumulated in the river estuary.

Phosphate levels at station III are lower than those of phosphate at station I and station II due to its increasingly farther out sea. The concentration of phosphate found in the estuary waters of Saddang indicates that the waters are quite fertile. This is in line with Wardoyo in 1982, fertility rate of fertile waters based on phosphate levels ranging from 0.0021-0.050 mg/l and fertile waters ranging from 0.051-0.100 mg/l [33] and EPA (2002) also stipulate that phosphate is classified high in sea waters i.e. >0.096 mg/l [37].

Phosphate is an important factor for the growth of phytoplankton and other organisms. Phosphate is indispensable as the transfer of energy from the outside into the cells of the organism, and phosphate is needed in small quantities (slightly). A phosphate is a form of phosphorus that can be used by plants [16]. The utilization of phosphates by phytoplankton occurs during the process of photosynthesis. When phytoplankton dies, organic phosphorus quickly turns into phosphate. Many phytoplankton is eaten by zooplankton which in the process produce phosphates.

The decomposition process of dead phytoplankton also plays a role with the help of bacteria to produce inorganic phosphorus. Due to the need for phytoplankton growth, the optimum orthophosphate range is 0.09–1.80 ppm [34]. Orthophosphate compounds are a limiting factor when the level is below 0.004 ppm, while at levels over 1.0 ppm PO4-P can cause blooming. High concentrations of phosphate in water can lead to phytoplankton blooming and lead to dominance in certain phytoplankton species [38]. The source of phosphorus in natural waters comes from weathering mineral rocks and from the decomposition of organic matter, in addition, phosphorus is also found in industrial and domestic waste from human activities [16].

3.3. Community Structure and Phytoplankton Abundance

A community structure is an individual arrangement of several types or species that are organized to form a community. Community structure can be learned by knowing one or two specific aspects of the organism of the community in question such as diversity, zoning, or stratification. The structure of the community naturally depends on the pattern of spread of organisms in the ecosystem.

Generally, the organism spreads in three ways, first drifting or following the direction of wind or water, the second moves actively by swimming or flying, the third attaches to a moving object. In general, plankton spreads by drifting or following the current. According to Krebs in 2009, community structure has five characteristics namely diversity of types, forms of growth and structure, dominance, relative abundance, and tropical structure [39].

Phytoplankton identification results during the study were found as many as four classes namely Bacillariophyceae consists of 17 genera namely Amphiprora, Bacteriastrum, Biddulphia, Chaetoceros, Coscinodiscus, Ditylum, Eucampia, Fragilaria, Guinardia, Lauderia, Navicula, Nitzchia, Pleurosigma, Rhizosolenia, Synedra, Thalassiothrix, Thalassionema, then Chlorophyceae as many as 1 genus namely Pediastrum, Cyanophyceae with 1 genus namely Oscillatoria, and Dynophyceae as many as 6 genera namely Ceratium, Dinophysis, Gymnodium, Protoperidinium, Prorocentrum, and Pyrocystis.

Based on abundance data (Figure 2), Station I is the station that has the highest amount of phytoplankton abundance of 57 Cells/L, furthermore station II with an average abundance of 44 Cells / L and the lowest at station III with an average abundance of phytoplankton that is 31 Cells / L. Although the abundance of phytoplankton differs between stations, statistically based on Anova tests, the abundance of phytoplankton between stations is considered the same ($p>0.05$).

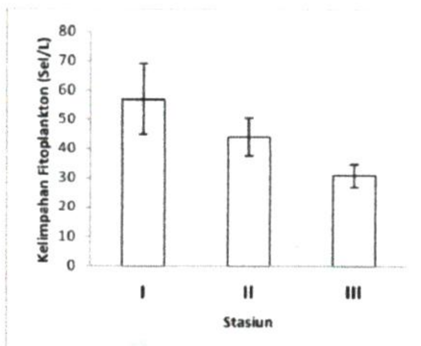

Figure 2. The average abundance of phytoplankton between stations.

The phenomenon of the high abundance of phytoplankton in station I is compared to stations II and III and if connected with parameters related to phytoplankton growth, this could happen. One of the reasons is alleged because station I is close to residential houses so that the waters get a lot of nutrient input. Daily community activities affect the high waste disposal so that the waters get a lot of inorganic material input. It can also be seen with the high phosphate nutrients in station I when compared to station II and station III.

Based on the most genus identification results found, Navicula of the Bacillariophyceae class was found to be the highest at Stations I and II, Oscillatoria of the Cyanophyceae class at station III. Based on that it can be explained that the genus Navicula and Oscillatoria are the most common types of phytoplankton found throughout the research station. The highest abundance in the genus Navicula is thought to be because the Bacillariophyceae class is a type of phytoplankton capable of living and developing in various aquatic conditions both in fresh water and water with high salt content [3] and has a widespread (cosmopolitan). Similarly, the genus Oscillatoria of the class Cyanophyceae. It is also explained by Ramadani et al. in 2013 that the high abundance of phytoplankton of the

Bacillariophyceae class is due to phytoplankton belonging to this class are widespread in estuary waters to the sea and its more dominant presence in the water [40]. The three genera can adapt well in the estuary waters of Saddang Pinrang Regency. This is similar to tambaru et al in 2018 statement that the type of phytoplankton that will dominate water is a type that can adapt to its environment [41].

The feasibility of a habitat for a community can be systematically measured by analysis of species diversity [42]. This is based on the idea that both populations and communities over time and between habitats with each other will have a specific community pattern (structure) according to the environmental factors that affect it [43]. These differences are essentially characterized by the composition of the species and the abundance of individual constituents of the population concerned.

3.4. *Relationship between Phytoplankton Abundance with Salinity and TSS*

Based on the results of the correlation test analysis obtained that salinity has a significant relationship ($p<0.05$) to the abundance of phytoplankton with a correlation coefficient value of -0.499 that shows a moderate relationship. This is similarly explained by Astuti (2017) that the correlation coefficient value between 0.41 – 0.70 has a moderate relationship strength.

The correlation between salinity and phytoplankton abundance shows a negative relationship. This indicates that with the increasing value of salinity in the waters of the Saddang estuary, the value of phytoplankton abundance will decrease. According to Kaswadji et al. (1993), salinity affects the rate of photosynthesis, especially in estuary areas, especially in phytoplankton that can only survive at small salinity boundaries (stenohaline).

The above is in line with research conducted by Pratiwi et al. in 2015 in the waters of Malang Rapat Kabupaten Bintan Riau Islands Province that every increase of one unit of salinity in the water, the abundance of phytoplankton will decrease by 0.15 units assuming other parameters are fixed and this condition shows a negative relationship between the abundance of phytoplankton to salinity [11].

Seriously, the relationship between phytoplankton abundance and total suspended solids (TSS) is inversely proportional to salinity. This suggests that TSS is not good ($p>0.05$) changes in phytoplankton abundance in the estuary Saddang Pinrang District.

3.5. *Ecological Index*

3.5.1. Diversity Index (H'). The diversity index (H') values of phytoplankton obtained at each station I, II, and III are 1.60, 1.87, 2.03, respectively. Based on these values, phytoplankton diversity is in the moderate category ($1 < H' < 3$) [22]. This indicates that phytoplankton growth is in the category of both to grow and develop. It can also be supported by previous research by Pirzan and Pong-Masak in 2016 in the coastal area of Ppinrang Regency which gets a diversity value of 2.21 which means the phytoplankton community is classified as moderate [38].

3.5.2. Evenness index (E). The average range of phytoplankton uniformity index (E') values in the Saddang estuary water region averages around 0.72, 0.80, 0.87. This indicates that phytoplankton has a moderate level of uniformity or community in stable condition ($0.75\ E \leq 1$) in other words that the growth of each type of phytoplankton is equal or even [39]. This suggests that the Saddang estuary has phytoplankton with viable growth. This is also supported by research conducted by Pirzan and Pong-Masak (2016) with a uniformity index value of 0.75.

3.5.3. Dominance Index (D). The average range of phytoplankton dominance index (D) values obtained in Saddang estuary waters is between 0.16, 0.21, 0.28. This suggests that the abundance of each genus of phytoplankton on the research station is inequitable condition and nothing dominates. Odum (1971) states that if the value of D approaches 0 it means that almost no individual dominates and is usually followed by a large E value (close to 1), whereas if the value of D approaches 1 means that there is a certain type of dominance and is characterized by a smaller E value or close to 0 [22]. Previous research conducted by Pirzan and Pong-Masak in 2016 obtained a low dominance index value of 0.15 [38].

4. Conclusion

Based on research that has been done can be concluded that salinity has a real effect and shows a moderate and negative relationship to the abundance of phytoplankton. In contrast, total suspended solids (TSS) showed no real link to the abundance of phytoplankton in the estuary waters of Saddang river Pinrang regency.

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