Analysis of primary productivity and trophic status of Kuala Gigieng waters Aceh Besar for sustainable fisheries management

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Abstract. Kuala Gigieng is one of the estuary areas in Aceh Besar Regency. This research is about the analysis of chlorophyll-a and trophic status of Kuala Gigieng waters in the context of sustainable fisheries management. This research was conducted in April 2019 in the water of Kuala Gigieng. This study aims to determine the trophic status of the waters, the value of chlorophyll-a and the abundance of phytoplankton in the Kuala Gigieng waters. Determination of observation stations using random stratified sampling method. Analysis of chlorophyll-a using the Trichomatic method. Analysis of the trophic status of the waters with the Trix method. The results showed that the waters of Kuala Gigieng were categorized as high fertility (eutrophic). The value of chlorophyll-a ranged from 0.21 μg/l – 5.56 μg/l, and the value of net primary productivity (NPP) ranged from 3.47-27.77 mgC/m³/hour and the value of gross primary productivity (GPP) ranged from 5.20-32.98 mgC/m³/hour. Meanwhile, the abundance of plankton ranged from 133.33-207.40 ind/l. Water quality parameters are still suitable for the growth of plankton in Kuala Gigieng waters.

1. Introduction
Kuala Gigieng is one of the estuary areas in Aceh Province which is located in Aceh Besar District. These waters have the potential of marine fisheries include fisheries, ponds and rivers. Estuary areas are rich in nutrients that can support the life of other aquatic organisms including phytoplankton. Various activities occur in the waters of Kuala Gigieng, including household waste activities, aquaculture, fishing and transportation that have the potential to have a negative impact on the waters. so that directly or indirectly will cause changes in the physical, chemical and biological quality of the waters. Rudiyanti [1] states that water quality degradation can occur due to changes in water quality parameters. One of the organisms that have an impact on decreasing water quality is phytoplankton.
Phytoplankton plays a very important role in the waters including the role as primary producers and the beginning of the chain in the food web so that phytoplankton can determine the fertility of a waters [2,3]. Indicator of the trophic state of a water that can be measured from the nutrients, brightness and other biological activities which include the concentration of chlorophyll-a. Chlorophyll is one of the parameters that determine primary productivity in waters. The distribution concentrations of chlorophyll-a are closely related to the physical – chemical conditions of a waters [4,5].

Primary productivity is a description of the activity of chlorophyll plants in producing organic matter. The value of primary productivity is closely related to the intensity of light and nutrients [6,7]. The presence of nutrients affects the trophic status of waters. Trophic status is a description of the total concentration of phosphorus (essential substances for algae growth), the concentration of chlorophyll-a and the visibility of waters. The distribution of light and nutrients in the waters is generally not compatible with the needs of phytoplankton. Turbidity causes differences in the growth of phytoplankton in the waters. This will affect the primary productivity of phytoplankton. The presence of phytoplankton as natural food can indicate the potential of fish in the waters. Hence, the purpose of this study was to determine primary productivity, trophic status, chlorophyll-a value and abundance of phytoplankton in Kuala Gigieng waters.

2. Research Methods

2.1. Sampling
This research has been carried out in the waters of Kuala Gigieng, Aceh Besar District, Aceh Province. The research was conducted in April 2019. Station determination using random stratified sampling method. Sampling was carried out at five station. Station one is located at the entrance of seawater to Kuala Gigieng. The second station samples were taken near the mine quarry sand. Station three is located at the estuary body from the waters of Kuala Gigieng. Station three is located on the estuary body of Kuala Gigieng. The fourth station was taken at the mangrove ecosystem and station five was taken at residential areas. The map of the research is shown in Figure 1.
Sampling of phytoplankton using plankton net and plankton enumeration was carried out using the Census method. Measurement of primary productivity using oxygen method light-dark bottle with an incubation period of 6 hours. Phytoplankton biomass was calculated based on the chlorophyll-a. Analysis of chlorophyll-a using the Spectrophotometirc method [8]. Measurement of water physicochemical parameters is carried out in situ (directly) including: temperature, salinity, pH, DO, Visibility. Total nitrogen and phosphate were measured by Spectrophotometric method.

2.2. Data analysis

The formula used to measure primary productivity in waters is as follow [2]

\[
\text{Gross Primary Productivity (mgC/m}^3/\text{hr}) = \frac{(O_2\text{LB})-(O_2\text{DB}) \times 1000}{(PQ)(t)} \times 0.375
\]

\[
\text{Net Primary Productivity (mgC/m}^3/\text{hr}) = \frac{(O_2\text{LB})-(O_2\text{DB}) \times 1000}{(PQ)(t)} \times 0.375
\]

where \(O_2\text{LB}\) is concentration of oxygen in the light bottle; \(O_2\text{DB}\) is concentration of oxygen in the dark bottle; \(PQ\) is coefficient of photosintetic=1.2; \(t\) is time of incubation (6 hours); 0.375 is ratio of carbon and oxygen atomic mass.

Phytoplankton abundance was calculated using field view method by using the formula [8]:

\[
N \text{ (ind/l) = } n \text{ (ind) } \frac{Vt (ml)}{Vcg (ml)} \times \frac{Acg (mm)^2}{Aa (mm)^2} \times \frac{1}{Vd (l)}
\]

Chlorophyll-a was calculated by the Trichomatic method [8,9]:

\[
\text{Chlor} - a \text{ (mg/l) = } \frac{((11.85 \times E664) - (1.54 \times E647) - (0.08 \times E630)) \times ve}{Vsxd}
\]

Analysis of trophic status using the TRIX method [10]:

\[
TRIX = \left[ k \sum_{i=1}^{n} \left( \frac{\log M - \log L}{\log U - \log L} \right) \right]
\]

Classifies the limit of the TRIX index value as follows: TRIX < 2 = oligotrophic; 2 ≤ TRIX < 4 = mesotrophic; 4 ≤ TRIX < 6 = eutrophic; TRIX ≥ 6=hypereutrophic [10].

3. Results and Discussion

3.1. Primary productivity

Aquatic productivity is the rate of energy storage by the autotrophic community in the waters [2]. The difference in primary productivity values at each observation station in Kuala Gigieng is caused by differences in the activity of autotrophic organisms. The results of gross and net primary productivity can be seen in Table 1.

| No | Parameter                        | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 |
|----|----------------------------------|-----------|-----------|-----------|-----------|-----------|
| 1  | NPP (net primary productivity)   | 3.472     | 5.028     | 10.417    | 13.889    | 27.778    |
|    | (mgC/m³/hour)                    |           |           |           |           |           |
| 2  | GPP (gross primary productivity) | 8.681     | 32.986    | 27.778    | 5.208     | 12.153    |
|    | (mgC/m³/hour)                    |           |           |           |           |           |

Table 1 shows that the highest NPP value is found at station five of 27.778 mgC/m³/hour, this is influenced by the high abundance of plankton so that it has an impact on net photosynthetic production. Besides that, because station five is a residential area, it is suspected that the high contribution of nutrients from household activities. The highest total nitrogen and phosphate values at
station 5 were 0.31 mg/l and 0.832 mg/l, respectively. Retnoningtyas [11] stated that the value of the primary productivity of the Thousand Islands ranged from -46.88 to 39.06 mgC/m³/hour. In addition, Alianto et al. [6] conducted a study on primary productivity in Banten Bay getting a value of 14.15 to 29.59 mgC/m³/hour.

When compared with the primary productivity value of the estuary in Muara Kuala Raja, which was 209.12 mgC/m³/hour and 172.00 mgC/m³/hour [2], the primary productivity value of Kuala Gigieng is relatively low. This is inseparable from the presence of dissolved nutrients on the surface of the waters such as ammonia, nitrates, and silicates [6,12,13].

3.2. Plankton abundance

The composition of plankton types in Kuala Gigieng waters consists of 4 classes, namely: coscinodiscophyceae, cyanophyceae and mediophyceae and maxillapoda. Measurement of plankton abundance was carried out at five stations with an overall average value of 168.888 ind/l. The highest abundance of plankton was found at station 3 with a value of 207.40 ind/l, and the lowest value at station 2 was 133.33 ind/l (Table 2).

The existence of phytoplankton is influenced by water conditions so as to produce different species communities [14,15,16]. According to Onyewa [17] the composition of phytoplankton is not always evenly distributed in the water column. Research conducted in Gajah Mungkur Reservoir by Pujiastuti et al. [18] produced phosphate values in the range of 0.06-0.37 mg/L. The high concentration of phosphate compounds is influenced by nutrient intake from water catchment areas, population activities and aquaculture activities.

| No | Parameter          | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 |
|----|--------------------|-----------|-----------|-----------|-----------|-----------|
| 1  | Abundance of plankton | 148.14 ind/l | 133.33 ind/l | 207.40 ind/l | 162.96 ind/l | 192.59 ind/l |

3.3. Trophic status of Kuala Gigieng waters

The concentration of chlorophyll-a is an indicator in determining the trophic status of a waters. Based on the results of observations of the status trophic Kuala Gigieng with the trix method, it is classified as eutrophic with a value of 5.81 (Table 3).

The high trophic status in the waters of Kuala Gigieng is thought to be due to the high activity of the local community. The high level of household waste can be seen from the high value of nitrate and phosphate in this area. Trophic status will increase with increasing anthropogenic activities in water bodies [19]. Phosphate compounds are used as a limiting factor for water fertility which is closely related to the composition of phytoplankton [4,20].

Xiangcan [21] found that the waters of Caiwobao Lake in China are lakes that have low levels of chlorophyll-a (classified as oligotrophic), while the content of total N and total P is very high (classified as hypertrophic). Karina et al. [5] phytoplankton abundance and Chlorophyll-a concentration play an important role in affecting the trophic level of waters. The research of Karina et al. [5] obtained the highest chlorophyll-a value in Ujung Pancu waters of 2.05 μg/l. Chlorophyll-a is a
parameter in classifying the trophic conditions of a waters. The value of chlorophyll-a in the waters of Kuala Gigieng ranged from 0.21 to 5.56 µg/l. This value is in line with the high value of nitrate and phosphate in the waters of Kuala Gigieng. Nitrate and phosphate determine the growth rate of phytoplankton and the efficiency of photosynthesis [13].

4. Conclusion
The trophic status of Kuala Gigieng waters is eutrophic with chlorophyll-a values ranging from 0.21-5.56 µg/l, and net primary productivity values ranging from 3.472-27.778 mgC/m³/hour and gross primary productivity values ranging from 5.208-32.986 mgC/m³/hour.

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