Biological Oxygen Demand ($\text{BOD}_5$) as Bio Indicator of Phytoplankton Diversity Index in The Mangrove Area of Kintap Estuary - South Kalimantan

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Abstract. Indonesia as a country that has the largest mangrove area in the world, of course contributes significantly to global climate change. It is known, the mangrove area is an area with abundant biodiversity. The existence of various industrial activities, such as oil palm plantations or special coal port operations make the mangrove area can receive negative impacts. Bio-indicators are living organisms such as plants, planktons, animals, and microbes, which are utilized to screen the health of the natural ecosystem in the environment. They are used for assessing environmental health and bio geographic changes taking place in the environment. The ability of microorganisms to reform the biodegradation process is an indicator of pollutants in the waters. In the process, microorganisms require or consume more dissolved oxygen (DO). So, the higher the concentration of $\text{BOD}_5$, the concentration of dissolved oxygen (DO) in water is reduced. This research uses the grab sampling method, which is done 4 times in one year for water quality sampling ($\text{BOD}_5$) and aquatic biota samples. The results of this research, showed a significant positive correlation regarding the concentration of $\text{BOD}_5$ on biodiversity in mangrove areas. Thus, $\text{BOD}_5$ concentration can also be used as an bio-indicator of the quality biodiversity of mangrove areas.

1. Introduction

Mangrove areas are an abundant source of biodiversity sustainability. Many factors that are indicators of a mangrove area on estuary are a complex ecosystem. One of the key parameters used for indicators of surface water quality is $\text{BOD}_5$ and the phytoplankton is used to see the level of aquatic fertility. The relationship between $\text{BOD}_5$ and phytoplankton is theoretically very closely related. Where, when microrganism require a lot of oxygen for the degradation process which is indicated by increasing $\text{BOD}_5$ concentrations, so that in the condition of lack of dissolved oxygen in the water, it can interfere with photosynthesis by phytoplankton. The correlation of these two indicators is the focus of research.
Mangrove habitat is one of the most productive ecosystems on Earth, lying between the land and the sea on tropical and subtropical. Mangrove ecosystem’s productive characteristics are governed by a complex interaction between its biotic and abiotic components. Mangroves have the capacity to efficiently trap suspended material from the water column. Litter from mangroves (leaves, propagules, and twigs) and subsurface root growth provide significant inputs of organic carbon to mangrove sediments. Mangroves in the estuarine ecosystem play important roles in biodiversity and energy flow, and in maintaining functioning food chains, with phytoplankton playing a vital role as a primary producer. Phytoplankton initiates the marine food chain by serving as food to primary consumers such as zooplankton, shellfish, and finfish [5].

Mangroves are a diverse species of tropical woody trees found primarily in Tropical and Sub-tropical intertidal (wetland) environments. They are estimated to cover a global area of between 137,760 and 152,000 km². Mangroves provide a suite of regulating, supporting and provisioning ecosystem services including shoreline protection, carbon sequestration and storage, water quality enhancement and promoting high biodiversity by providing food and shelter for fish, marine invertebrates, and birds [9]. Biochemical oxygen demand (BOD) is a widely used parameter to assess the organic pollution in water systems. This parameter can be detected by the amount of oxygen consumed via microorganisms in aerobic metabolism of organic matter present in the water.

The authorized test to analyze biodegradable organic compounds is given by the American Public Health Association Standard Method Committee that is called a 5-day biochemical oxygen demand (BOD₅) test [2]. Microorganisms are often used as health indicators of aquatic and terrestrial ecosystems. Due to their abundance, they are easy to test and readily available. In many water bodies, such as, seas, lakes, streams, and swamps, significant biological production is carried out by plankton. Planktons are composed of organisms with chlorophyll (i.e. phytoplankton and animals such as zooplanktons). These planktons consist of communities that float along currents and tides, yet they fuse and cycle important quantities of energy that is then passed on to higher trophic levels. Planktons react rapidly to ecological changes and are viewed as excellent indicators of water quality and trophic conditions due to their short time and rapid rate of reproduction. Plankton also plays an important role in biological deterioration organic matter; but if plankton populations are too large this creates other problems in managing the water body [7]. The primary component of plankton are phytoplankton [8].

The availability of phytoplankton influences the distribution of consumer organisms, such as immediate herbivore zooplankton. In addition, phytoplankton have a high nutrient content, which makes them a valuable food item in the aquatic food chain. Thus, in the food web of estuarine ecosystems, phytoplankton play an important role. Generally, estuaries are very productive zones because they concentrate nutrients from rivers, and have a nutrient trap effect due to mixing with sea water (floculation) and local retention due to tidal changes [5]. Bio-indicators are living organisms such as plants, planktons, animals, and microbes, which are utilized to screen the health of the natural ecosystem in the environment. They are used for assessing environmental health and bio geographic changes taking place in the environment [7]. Bio-indicators are relevant for ecological health.

Ecological health can be viewed in terms of ecosystems, where by structural and functional characteristics are maintained. Bio-indicators are used to: detect changes in the natural environment, monitor for the presence of pollution and its effect on the ecosystem in which the organism lives, monitor the progress of environmental cleanup and test substances, like drinking water, for the presence of contaminants. In traditional bioassays, a bio-indicator organism or organisms association are introduced to environmental samples, such as soil or water, and researchers observe any changes that occur as a result of exposure. These methods are based primarily on observation to detect changes [6]. Phytoplankton assemblages are generally more sensitive to pollution than other assemblages. Therefore, they are the best biological indicators of
pollution in the aquatic habitat. The use of phytoplankton for water quality assessment has a long history.

Classification schemes based on phytoplankton biomass were developed from more than 20 years ago. The water ecosystems are consisting of hydro-chemical and biological variables, which are extremely complex, partly due to the strong influence of the many different sources of pollution such as industrial, thermal, urban and agricultural [4]. Phytoplankton that are buried are generally found in waters around estuary, where tidal currents occur (upwelling). Where nutrients enter the area, causing the process of aquatic fertility [3]. Estuaries receive larger nutrient inputs than any other ecosystem type. Nutrient supply to estuaries is strongly influenced by human activities, and changes in nutrient supply over time have caused significant changes in phytoplankton biomass and production, especially since the mid 20th century. Empirical observations over decades have established a strong association between river discharge and phytoplankton primary production in estuaries [1]. This research uses the grab sampling method, which is done 4 times in one year for Biological Oxygen Demand (BOD$_5$) and pytoplankton samples.

Table 1. BOD analysis at Estuary Kintap

|       | Year | Station 1 (mg/l) | Station 2 (mg/l) |
|-------|------|-----------------|-----------------|
| Feb   | 2015 | 64.69           | 78.86           |
| May   |      | 3.86            | 7.03            |
| Sept  |      | 54.31           | 62.71           |
| Dec   |      | 0.87            | 0.43            |

Source: Regional Health Laboratory, Bogor

Figure 1. Sampling point
2.1 Biological Oxygen Demand (BOD5)

Water quality sample taken by using grab sampling relate at SOP EPA No : 2013, 1994. Parameter analysed of BOD5 conducted by the laboratory, in this case becoming examination laboratory is Regional Health Laboratory, Bogor. (KAN Accreditation, LP 443-IDN). Preservation of sample relate to Recommendation for Sampling and Preservation of samples, arranged according to measurement, EPA-600/4-79-020 US. EPA, USA. Methods for Chemical Analysis of Water and Waste.

Table 2. Phytoplankton analysis at EstuaryKintap, South Kalimantan, 2015

| Month | Divisi/Phylum | Genus      | ST1 | Station2 |
|-------|---------------|------------|-----|----------|
| June  | Bacillariophyta| Thalassiosiraceae | 6   | 6        |
|       |               | Stephanoprypis | 4   | 4        |
|       |               | Rhysoselina limbricata | 6 | 4        |
|       | Taxa          | 3           | 3   |          |
|       | Individuals   | 16          | 14  |          |
|       | Dominance     | 0.3438      | 0.3469 |        |
|       | Simpson index | 0.6563      | 0.6531 |        |
|       | Evenness      | 0.9837      | 0.9806 |        |

|       | Cyanophyta    | Anabaenia   | 3   | 0        |
|       |               | Anacystis   | 5   | 3        |
|       |               | Osciatoria   | 0   | 0        |
| June  | Rhodophyta    | Euchema spinosum | 5 | 4        |
|       | Bacillariophyta| Staunonies | 0 | 3        |
|       |               | Melosira    | 2   | 0        |
|       | Taxa          | 4            | 3   |          |
|       | Individuals   | 15           | 10  |          |
|       | Dominance     | 0.28         | 0.34 |        |
|       | Simpson index | 0.72        | 0.66  |        |
|       | Evenness      | 0.9386      | 0.9903 |        |

| September | Divisi/Phylum | Genus          | ST1 | Station2 |
|-----------|---------------|----------------|-----|----------|
|           | Rhodophyta    | Euchema spinosum | 6   | 4        |
|           | Bacillariophyta| Skletonema     | 0   | 0        |
|           |               | Thalassiosiraceae | 4 | 4        |
|           | Taxa          | 2             | 2   |          |
|           | Individuals   | 10            | 8   |          |
|           | Dominance     | 0.52          | 0.5  |        |
|           | Simpson index | 0.48         | 0.5  |        |
|           | Evenness index| 0.8601       | 1    |        |

| December | Divisi/Phylum | Genus          | ST1 | Station2 |
|----------|---------------|----------------|-----|----------|
|           | Bacillariophyta| Leptocylindricus danicus | 4 | 8        |
|           |               | Fragilaria Lyngbye | 0 | 6        |
|           |               | cocconeis        | 6   | 6        |
|           |               | Licmophora       | 0   | 0        |
|           | Taxa          | 3             | 4   |          |
|           | Individuals   | 14            | 32  |          |
|           | Dominance     | 0.3469        | 0.2734 |       |
|           | Simpson index | 0.6531        | 0.7266 |       |
|           | Evenness      | 0.9806        | 0.9568 |       |
2.2 Phytoplankton

Sampling and preparation of samples of macro invertebrates referring to “Standard Method for Examination Water and Wastewater 21st edition”, 2005. Plankton sampling is done by taking as much as 50 l. The collected water is then filtered with 25 size plankton net which has 200 mesh per inch. The plankton net equipped with 50 ml plankton bottle. Furthermore, plankton samples are preserved with formalin 4% and stored in the dark place. The sample analysis by Enviro Laboratory of Ganesha Violet using 200x magnification of USB microscope. Sampling points for BOD5 and phytoplankton can be seen in the figure 1.

2. Results & Discussion

Based on laboratory analysis data, the BOD5 concentrations at the two sampling stations are still within normal limits. The complete results of BOD5 analysis can be seen in the table 1. Likewise with the phytoplankton parameter, it also show the condition of unpolluted of surface water (see table 2).

Table 3. Linear correlation analysis between BOD5 and phytoplankton

| ST 1       | BOD       | Plankton |
|------------|-----------|----------|
| Feb        | 64.69     | 0.6563   |
| May        | 3.86      | 0.72     |
| Sept       | 54.31     | 0.48     |
| Dec        | 0.87      | 0.6531   |
| Linear Correlation, r | -0.5594 |

| ST 2       | BOD       | Plankton |
|------------|-----------|----------|
| Feb        | 79.86     | 0.6531   |
| May        | 7.03      | 0.66     |
| Sept       | 62.71     | 0.5      |
| Dec        | 0.43      | 0.7266   |
| Linear Correlation, r | -0.6018 |

The results of the liear analysis show the negatif (-) value. This means it has opposite characteristics. When BOD5 is high, the diversity index of phytoplankton will be low, and vice versa. This is consistent with research assumptions, when high BOD5 will be followed by reduced dissolved oxygen (DO). While dissolved oxygen (DO) needed by phytoplankton life, the diversity index of phytoplankton will also decrease.

3. Conclusions

The BOD5 parameter can be used as an bio-indicator of the phytoplankton diversity index. Determination of BOD as bio-indicator is useful to give a general description of conditions of the phytoplankton diversity index. Further research is needed to refine the results of this research.

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