Tropic Level Status of Dumai River Estuary Based on Chlorophyll-Content

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Abstract: Chlorophyll-a, an active pigment found in phytoplankton, is an indicator of phytoplankton biomass and can be used as an indicator of tropic level status of a waters. Dumai River estuary, a transition zone between river and maritime environments of Rupat Strait, are subject both to marine influences, such as tides, waves, and the influx of saline water, and to riverine influences, such as flows of fresh water and sediment. The mixing of sea water and fresh water provide high levels of nutrients both in the water column and in sediment, making estuaries among the most productive natural habitats in the world. The number of surrounding industrial and domestic activities can lead to changes in the ecosystem of the estuary. This study aims to assess the distribution of chlorophyll and tropical level status of the waters of the estuary of Dumai River. It was noted that the content of chlorophyll-a Dumai River estuary ranges from 0.75 to 2.26 ug/l, in which the highest level was at station 3. Based on tropical level criteria, the waters of Dumai River estuary is indicated as oligotrophic to mesotrophic waters, meaning that these waters are less productive.

Keywords: Estuary of Dumai River, chlorophyll-a, tropic level

1. Introduction

Dumai river flows along the outskirts of the Dumai city and empties into the Rupat Strait. A number of industrial and domestic activities are pollutant inputs that potentially lead to changes in the estuary ecosystem of the Dumai River both in terms of increasing pollutants and water fertility. This pollutant input can negatively affect coastal and marine environment (Puig et al 2015), either directly or indirectly. Chlorophyll-a is an active pigment found in phytoplankton which is very important in the process of photosynthesis formation of organic matter in the waters. Chlorophyll-a is an indicator of phytoplankton biomass (Boyer et al. 2009). Chlorophyll is identical to the presence of phytoplankton which is a source of nutrients for higher level marine organisms including nekton [5].
Phytoplankton growth which is the biomass of chlorophyll is strongly influenced by environmental conditions such as anthropogenic activity (Ukwe et al., 2003), climate and variability of physical oceanography (Hardman-Mountford and McGlade, 2002; Djakoure et al., 2014). Chlorophyll-a is an active pigment which is very important in the process of photosynthesis and the formation of organic matter in the waters. In general nutrient input required by aquatic organisms where the higher nutrients in a waters the higher the abundance of phytoplankton and chlorophyll-a concentration. Hakanson & Bryann (2008), mention that tropical status of coastal and estuarine waters consists of 4 (four) levels, including: oligotrophic, mesotrophic, eutrophic, and hypertrophic. Tropical level criteria include: oligotrophic waters of chlorophyll-a concentration: <2 ug / l, mesotrophic chlorophyll-a waters range from 2-6 ug / l, chlorophyll a-eutrophic waters ranging from 6-20 ug / l and hypertrophic waters of chlorophyll-a:> 20 ug / l. This research is aimed to study the status of tropic level of of Dumai River estuary based on chlorophyll-a content. The results of this study are expected to be usefull as scientific information on chlorophyll-a content of Dumai River estuary associated with the status of the tropic level of the waters.

2. Methodology

Samples were collected at low tide from 4 stations of waters of Dumai River estuary, Dumai City. Representing upstream segment (station 1), center (station 2 and station 3) and downstream (station 4). The sampling point taken at the study site is perpendicularly from the edge, center and edge by assigning three sampling points at each station. Data were obtained through direct measurement of dissolved oxygen parameters, temperature, current velocity, salinity, water brightness and pH of the waters of Dumai River estuary by using portable instrument. While the content of chlorophyll-a, nitrate and phosphate is done by sampling the water of the Dumai River estuary by using vandal water sampler and analyzed in the laboratory. Analysis of chlorophyll-a sample refers to APHA (2005), nitrate and phosphate of SNI (2004) using spectrophotometric method. The content of chlorophyll-a is then spatially visualized using ArcGis Maps 10.1 software to view the data of chlorophyll-a distribution in Dumai River estuary waters.

3. Result And Discussion

Dumai River is one of the rivers that divide Dumai City which leads to Selat Rupat, has a length of ± 15 km. Of the total length of the Dumai River is estimated ± 7.9 km (52.66%) of the riverbank area has become a residential area. Upper segment area is the area of Lake Bunga Tujuh with the activity of residential area and the processing of raw water into clean water. The middle segment is the residential area and urban activity while the downstream segment of the Dumai River is used as a means of transporting domestic ships, and transporting goods (Nedi et al., 2012). In situ water quality measurements, from upstream to downstream of the Dumai estuary indicate the range of numbers as follows; temperature (26-30 °C), current velocity (0.40-0.60 m/sec), water brightness (35-53 m), salinity (15-22 ppt), pH (5.9-6.9), dissolved oxygen (4.0-4.7mg / l), nitrate content (0.15-0.57 mg / l), phosphate content (0.010-0.041mg / l) and chlorophyll-a content (0.75-2.26 μg / l). The results showed that chlorophyll-a levels varied by station. The highest figures are recorded at station 3 and the highest on station 4. More detailed data are presented in the following table.
### Table 1. Results of water quality measurement of estuary of Dumai River.

| Station | Sampling point | Temp. (°C) | C. velocity (m/sec) | Brightness (cm) | Salinity (ppt) | pH | DO (mg/l) | Nitrate (mg/l) | Phosphate (mg/l) | Chlorofil-a (µg/l) |
|---------|----------------|------------|---------------------|-----------------|----------------|----|-----------|----------------|------------------|-------------------|
| 1       | 1.1            | 27         | 0.50                | 53              | 15             | 5.9| 4.7       | 0.27           | 0.031            | 1.56              |
|         | 1.2            | 28         | 0.60                | 50              | 16             | 6.1| 4.6       | 0.23           | 0.024            | 1.25              |
|         | 1.3            | 26         | 0.50                | 53              | 16             | 6.0| 4.5       | 0.25           | 0.027            | 1.50              |
| 2       | 2.1            | 28         | 0.50                | 49              | 18             | 6.1| 4.6       | 0.37           | 0.032            | 1.75              |
|         | 2.2            | 29         | 0.50                | 45              | 19             | 6.0| 4.4       | 0.35           | 0.030            | 1.73              |
|         | 2.3            | 27         | 0.50                | 50              | 17             | 6.2| 4.6       | 0.43           | 0.045            | 1.94              |
| 3       | 3.1            | 29         | 0.40                | 45              | 19             | 6.2| 4.3       | 0.55           | 0.040            | 1.54              |
|         | 3.2            | 28         | 0.50                | 48              | 18             | 6.4| 4.5       | 0.57           | 0.045            | 2.26              |
|         | 3.3            | 27         | 0.40                | 51              | 17             | 6.3| 4.6       | 0.53           | 0.041            | 2.23              |
| 4       | 4.1            | 29         | 0.40                | 40              | 20             | 6.8| 4.3       | 0.20           | 0.017            | 1.13              |
|         | 4.2            | 30         | 0.40                | 35              | 22             | 6.7| 4.1       | 0.17           | 0.014            | 0.91              |
|         | 4.3            | 30         | 0.40                | 30              | 21             | 6.9| 4.0       | 0.15           | 0.010            | 0.75              |

Chlorophyll-a is one of the parameters that determine primary productivity in the waters. According to Wetzel (2001), the concentration of chlorophyll-a is directly proportional to the phytoplankton biomass. Chlorophyll-a in aquatic ecosystem can be used as a measurement of primary productivity of phytoplankton, as it is commonly found in all phytoplankton species. The content of chlorophyll-a in the Dumai River estuary is more clearly illustrated in the following figure.

![Figure 1. Distribution of chlorophyll-a content at the mouth of the Dumai River.](image-url)
The figure shows, the highest chlorophyll content is at station 3 (2.01 μg/l), the high abundance of Chlorophyll-a at this location is due to the presence of water mass meetings at high and low tide which increase the number of nutrients directly through run off from land (Badylak & Philips, 2004., and Nedi, et al 2012). The lowest content of chlorophyll-a at station 4. The low chlorophyll-a value at this location is dominantly influenced by the marine ecosystem of Rupat Strait with lower nutrient content.

According to Hakanson & Bryann (2008), the criteria of tropical water level status based on chlorophyll-a content are: waters with chlorophyll-a concentration: < 2 μg/l are categorized into oligotrophic waters, waters with chlorophyll-a concentration: 2-6 μg/l is categorized as mesotrophic waters, waters with chlorophyll-a: 6-20 μg/l are categorized as eutrophic waters and waters with a-chlorophyll content: > 20 μg/l are categorized as hypertrophic waters. Based on chlorophyll content, the estuary of Dumai River grouped as oligotropic to mesotropic criteria indicating that the Dumai River includes less productive criteria. Factors of tidal and low tides and semi-enclosed nature of the estuary potentially affect the chlorophyll content at station 3. Based on Hakanson & Bryann (2008), the station 3 tropical level status is noted as mesotrophic criteria due to > 2.01μg/l. While other stations (stations 1, 2 and 4) categorized as oligotropic waters.

The content of a-chlorophyll in water is strongly influenced by various environmental factors, including current velocity, brightness and nutrient nitrate and phosphate content. Based on multiple regression analysis, the chlorophyll regression model in estuary of Dumai River is:

\[ Y = 0.025 + 0.199X_1 + 0.908X_2 + 0.512X_3 + 28.136X_4. \]

Current velocity (X1) has a positive effect on chlorophyll-a in the Dumai River estuary, the concentration of chlorophyll-a (μg/l) will increase with increasing current velocity. An increase in current velocity of 1 m/sec may increase the chlorophyll-a content by 0.199 μg/l (if the brightness, nitrate and phosphate constants variables).

Brightness of water (X2) has also a positive effect on chlorophyll-a content in the estuary of Dumai River. If the water brightness increases 1 metre, the chlorophyll-a level will increase by 0.908 μg/l with variable assumption of current velocity, nitrate and phosphate content are remains constants.

Similarly, nitrate content (X3) has positive effect on chlorophyll-a content in the waters, chlorophyll concentration will increase with nitrate concentration (mg/l). If the concentration of nitrate increases 1 mg/l then chlorophyll-a will increase by 0.512 μg/l assuming variable current velocity, brightness and phosphate are contant.

As in nitrate content, phosphate content (X4) has positive effect on chlorophyll-a content in estuary of Dumai River. If the phosphate content increases 1 mg/l, the chlorophyll-a level will increase by 18.12 μg/l in the estuary by assuming variable of current velocity, brightness and nitrate content are remains constant.

According to Lagus et al. (2004), nitrate and phosphate content are often limiting factors for growth and development of phytoplankton, both in freshwater and in estuary and marine waters. Nitrates and phosphates are the main nutrients utilized by chlorophyll-a for growth and development. The increasing number of nitrates and phosphates content in the waters will also increase the number of chlorophyll-a in the water. The highest content of nitrate and phosphate
was found in station 3 with a concentration of 0.55 mg/l and 0.042 mg/l of phosphate. The high nutrient content at this location is due to input from the mainland and semi-enclosed estuarine water conditions that are influenced by the semi-diurnal tidal water of Rupat Strait with tidal hoses twice daily. This condition has the potential to cause trapping of nutrients nitrate and phosphate in station 3.

Based on the determinant value ($R^2$), the contribution of current velocity variables ($X_1$), brightness ($X_2$), the content of Nitrate ($X_3$) and Phosphate ($X_4$) is 87.3% against chlorophyll-a, while 12.7% is determined by other variables outside the model.

4. Conclusion

The content of chlorophyll-a in the estuary of Dumai River ranges from 0.75-2.26 ug / L, and tend to increase from the river to the estuary and down from the estuary leads to the sea or Rupat Strait. Based on the chlorophyll-a content of trophic level status of Dumai River estuary is indicated as oligotrophic to mesotrophic criteria, meaning that the estuary less productive. The parameters of current velocity, water brightness, nitrate and phosphate contents have a significant contribution to the content of chlorophyll-a. Phosphate concentration has the greatest effect on chlorophyll content.

5. References

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