BIO Web of Conferences **74**, 04003 (2023) https://doi.org/10.1051/bioconf/20237404003
ISFM XII 2023

Horizontal distribution of chlorophyll-a and water quality on Delta Wulan Estuary, Demak Regency, Central Java, Indonesia

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Abstract. The overflow of water from the Wulan River has an impact on the amount of nutrients and pollutants that enter the Delta Wulan Estuary. Abundant nutrient content greatly affects the level of primary productivity, especially chlorophyll-a content. The study aimed to determine the horizontal distribution of chlorophyll-a and water quality in the Delta Wulan estuary waters. Sampling was carried out in June 2023 at 12 stations on Delta Wulan Estuary. Demak Regency. Based on the analysis results, the highest chlorophyll-a content was found at station 12 (10.59 - 12.20 mg/l). The nitrate content was found at station twelve (9.2 - 10.0 mg/l), and the highest value of phosphate content was found at stations 10 and 12, with a range of 0.22 - 0.25 mg/l. The range of sea surface temperatures ranges from 29.3 - 33.2°C. The salinity content value has ranged from 30.0 – 32.0 ppt. It can be concluded that water quality data can support the content of chlorophyll-a in the waters of the Wulan Delta Estuary.

1 Introduction

The Estuary Delta Wulan Waters is heavily influenced by the mass of water from the Wulan River during the rainy season. Meanwhile, during the dry season, seawater dominates the waters of the Estuary Delta Wulan. Morphologically, characteristics of Delta Wulan waters are strongly influenced by the mixing of low energy of freshwater seawater mass, and this affects the stratification of the water mass column in waters that are quite deep and for waters with low depths, causing the water mass to becomes homogeneous [1]

The characteristics mentioned above make the Delta Wulan Waters fertile. Therefore, the Estuary Delta Wulan Waters produces a variety of shellfish, shrimp, sea cucumbers, crabs, and other organisms.The existence of a supply of fresh water from the Wulan River causes fluctuating levels of salinity [2], which can affect the life of both benthic and pelagic organisms.

The composition and presence of benthic organisms, especially microphytobenthos, in various water conditions and substrates have been extensively studied [3–5]. The composition and abundance of microphytobenthos can be seen in its biomass by measuring

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the chlorophyll-a and total chlorophyll content to be seen as a source of primary productivity for basic substrates [6]. Primary productivity on the bottom substrate is very useful for benthic organisms, especially shellfish. This can be seen in the study of sediment characteristics on the population abundance of benthic organisms [3].

The waters of the Wulan Delta Estuary are very fertile mangrove areas because they have resources from the land and sea, so they are fertile habitats and also function as nursery grounds for several other benthic organisms.

Supply of domestic and anthropogenic waste will cause eutrophication in the Estuary Delta Wulan Waters.The enrichment process that occurs in the Delta Wulan Waters will cause phytoplankton blooms. If the blooming is a type of harmful phytoplankton, it will be dangerous for animals in the waters of the Wulan Delta Estuary.The ample supply of domestic waste will affect the productivity characteristics of The Estuary Delta Wulan Waters.The study aimed to determine the horizontal distribution of chlorophyll-a content and water quality in the Delta Wulan waters.

2 Materials dan Methods

This research was conducted in the Delta Wulan estuary with 12 stations (Figure 1). Sampling was conducted on 3 June 2023 to represent the dry season.

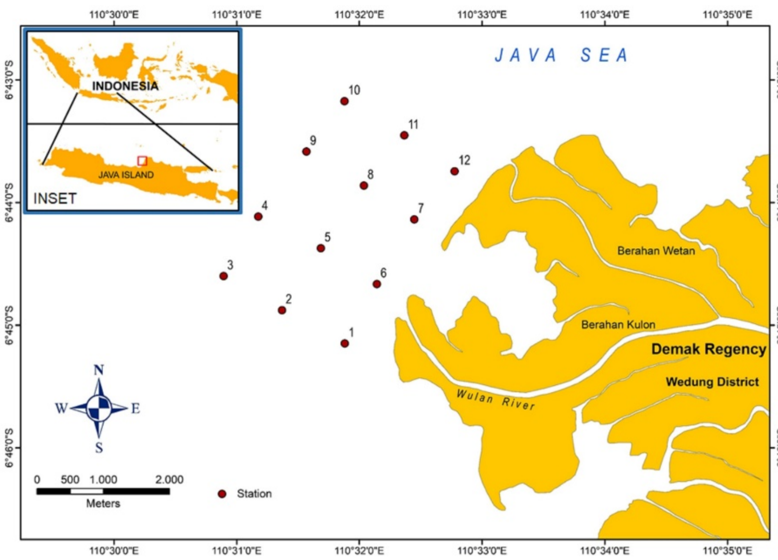

Fig. 1. Map of Sampling

Chlorophyll-a was measured by taking 1000 ml of water samples using a Niskin Bottle. The Chlorophyll-a measurement using the formula [7]

$$Chlorophyll - a \ (ug/l) \ = \frac{26.73(A663b - 665a)\ E}{\mathrm{V \times L}} \qquad (1)$$

Note: E = volume of acetone used for the extraction (10 mL); V = The volume of water filtered (L); L = The cell path length (cm); $A665_a$ = Absorption at 665 nm after acidification; $A663_b$ = Absorption at 663 nm before acidification

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2.1 Measurement of Water Quality

The Water temperature measurements carried out at 12 sampling stations. The Water temperature measurement is carried out by immersing the temperature sensor into the sea surface for some time until a constant number is obtained, then it is removed, and the temperature is immediately recorded [8].The salinity measurements are made by immersing the salinity sensor for a few moments until the value is constant and then recorded immediately. The pH measurement is carried out by immersing the pH sensor into the sea surface water for a few moments until the number on the tool shows a constant and does not change anymore. After that, the pH value was recorded.Likewise,TDS (Total dissolved suspended) and Conductivity are measured by immersing the sensor into the sea surface water for a few moments until the numbers are constant. Then just record the numbers that show the value of TDS and Conductivity [8].

2.2 Data Analysis

The Chlorophyll-a data analysis and supporting water quality parameters to describe horizontal distribution are using arc Map 10.3.1.

3 Result and Discussion

3.1 Chlorophyll-a

Based on the results of the research, the highest chlorophyll-a content was found at station 12 with a value of 12.29 μL^{-1}, and the lowest chlorophyll-a content was found at station 9 with a value of 0.27 μL^{-1}. (Fig. 2). Observation the horizontal distribution of chlorophyll-a, it is clear that chlorophyll-a is concentrated at stations 12 and 11. Meanwhile, at station 6, the concentration is not too high (Fig. 3 and 4). When it is related to the horizontal distribution of phosphate content, there is a relationship. The highest concentration of phosphate content is at station 12. The high content of chlorophyll-a at stations 12, 11, and 6 is because these stations are located in the river mouth area.The river mouth area is water that is rich in nutrients, causing a high content of chlorophyll-a [9]. The high content of chlorophyll-a indicates a high value of primary productivity. This can be seen in research in the Banda Sea and the River Mouth Bedono, whereas, an increasing in chlorophyll-a content is followed by an increase in net primary productivity and vice versa [15, 16].

Based on observations, the horizontal distribution pattern of phosphate content shows the same pattern as the horizontal distribution pattern of chlorophyll-a content. This shows that the water's phosphate content greatly determines chlorophyll-a's horizontal distribution pattern (Figures 3, 4, and 5).This is in accordance with the opinion of experts that phosphate is a limiting factor for the growth of phytoplankton. The mesocosms experiment in Daya Bay, Northern South China Sea shows that phytoplankton's phosphate and nitrate content can affect phytoplankton growth[10,11]. The horizontal distribution of phosphate and nitrate content has almost the same pattern, which certainly supports the horizontal distribution pattern of chlorophyll-a.

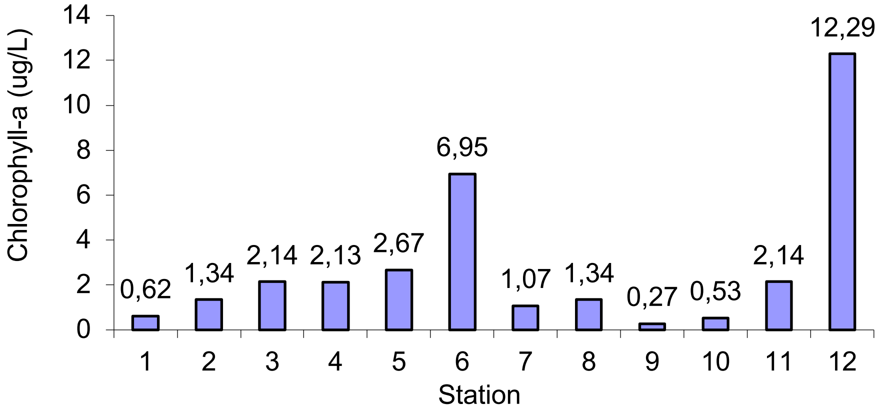


Fig. 2. The Chlorophyll-a content on Station 1-12 in the Delta Wulan Estuary

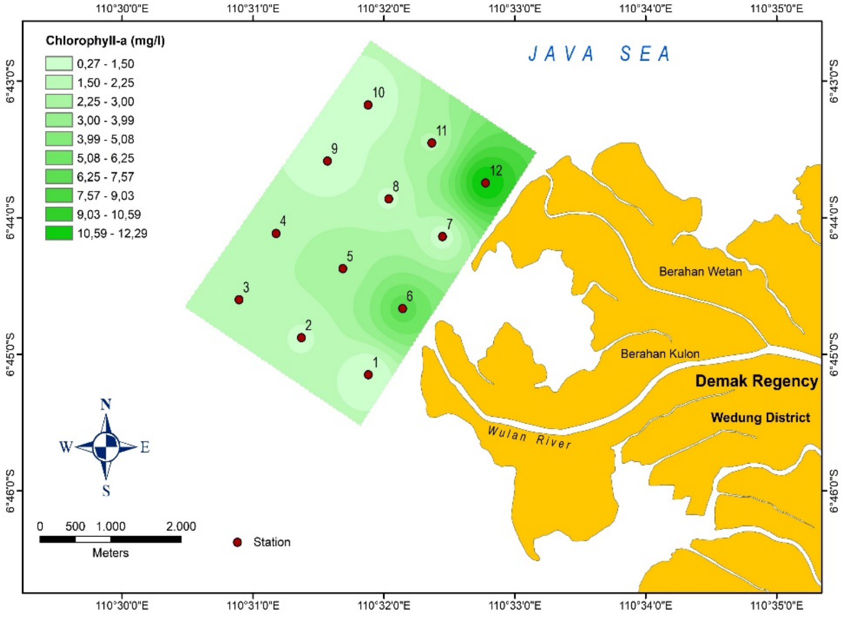
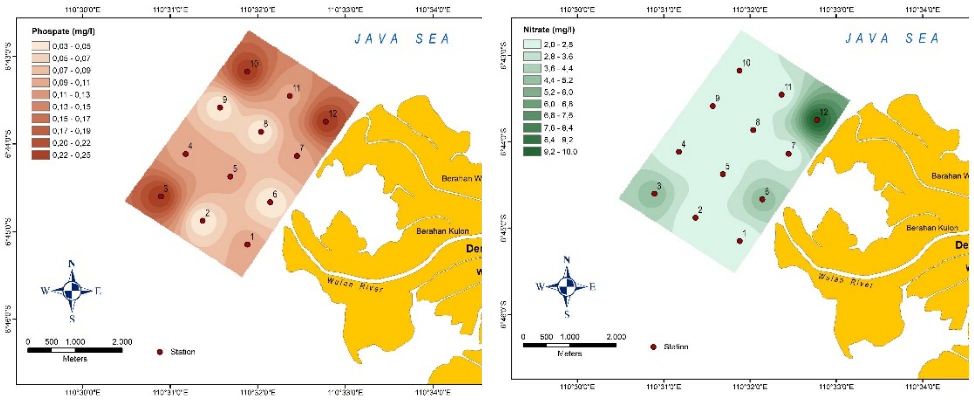


Fig. 3. The horizontal distribution of Chlorophyll-a (μg/L) in the Delta Wulan Estuary.

3. 2 Phosphate and Nitrate Content

The value range of phosphate is 0.03 – 0.25 ppm while, the value of nitrate is from 2.00 – 10.00 ppm. The high values of phosphate and nitrate at station 12 encourage growth in the chlorophyll-a content at station 12.The nitrate value in the Delta Wulan Estuary is quite high compared to the Banyuasin estuary, South Sumatra, with a value range of 0.025 – 3.121 ppm [12].The high nitrate value in the waters of the Wulan Delta Estuary is due to the intake of nitrate from the river.The primary source of nitrate is from household and agricultural waste, including animal and human waste.The condition of nutrients found in estuary waters is greatly influenced by human activities such as agricultural activities, pond activities along rivers, and anthropogenic activities [17]. The nitrate value in water is a macro-nutrient that controls primary productivity in water [12].

The range of nitrate values measured in the Delta Wulan Estuarine Waters has exceeded several quality standards that are used as references. The Ministry of Living Environment (2004) states that the threshold for nitrate values allowed for marine biota is 0.008 mg.L^{-1}. The threshold value for nitrate in waters set by the US-EPA (1973) is 0.07 mg.L^{-1}. High levels of nitrate can cause a eutrophication process which can be harmful to aquatic environmental conditions.



(a) (b)

Fig. 4. The horizontal distribution of phosphate content (a), and nitrate content (b) in the Delta Wulan Estuary.

Nitrate levels in the water column come from diffusion from the atmosphere to the water or vice versa, fixation, degradation of organic matter and organic waste [8], waste from agricultural land.The process of erosion and erosion on agrarian land allows nitrate that was previously trapped in the soil to enter rivers and empty into the sea. Agricultural, household, and aquaculture activities have provided a large supply of nutrients (N-P) along the Pangkep River in South Sulawesi [13].

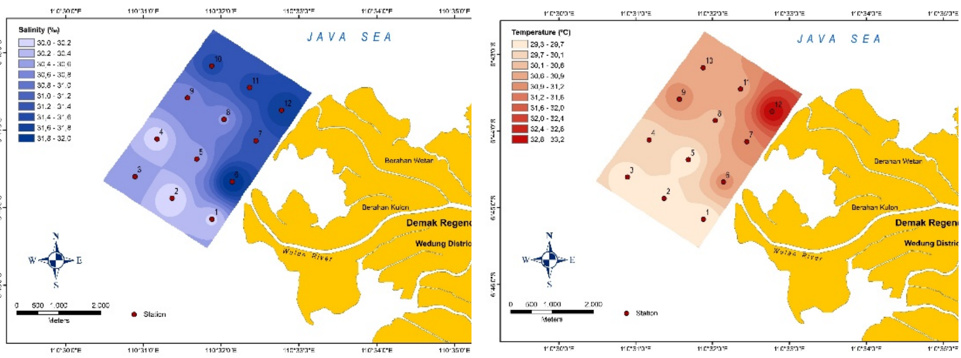
Phosphate levels measured in the Delta Wulan Estuarine Waters have a range of 0.03 – 0.25 ppm. The highest phosphate levels were found at stations 3, 10, and 12, with a value of 0.25 ppm, while the lowest were found at stations 2, 6. 8, and 9, with a value of 0.03 ppm. The range of phosphate levels measured in the Estuary Waters of the Delta Wulan is still higher than the Quality Standard value, which is 0.015 mg/L.The source of phosphate in water comes from the weathering of rocks, agricultural waste, and domestic waste, which enters the river and is forwarded to the river estuary [9]. The high phosphate levels accompanied by high nitrate will cause eutrophication with the growth of Cyanophyta [8].

3.3 Salinity Level and Water Surface Temperature

Based on observations of the distribution of salinity levels, the highest salinity was measured at station 6 with a value of 31.9 ppt and the lowest was found at station 2 with a value of 30 ppt and station 1, which was close to the mouth of the Wulan River was 30.2 ppt. Stations 1 and 2 are located west of the Wulan River Estuary. The low salinity levels at stations 1, 2, and 4 are due to the direction of the current from the east so that the low-salinity river current shifts slightly to the west of the river estuary (Figure 5.a).High surface temperatures of the waters also follow high levels of salinity are measurable.

Based on observations, the highest temperature was found at station 12 with a value of 33.3°C and the lowest at stations 1 and 5 with a value of 29.3°C.The further east, the higher the measured temperature value. If observed, the waters' temperature distribution pattern and surface salinity show the same distribution pattern (Figure 5a and 5b).

The flow of fresh water from the river causes interaction between fresh water and seawater. This interaction will greatly affect the distribution of temperature, salinity, and other water quality factors.Temperature changes can cause circulation and stratification water which directly or affect temperature changes which can cause circulation and stratification of water, which directly or indirectly will affect the distribution of aquatic organisms.If observed closely, the distribution pattern of temperature and salinity is the same as that of Chlorophyll-a, that temperature and surface water salinity affect primary productivity [14].



(a) (b)

Fig. 5. The horizontal distribution of salinity (a) and sea surface temperature (b) in the Delta Wulan Estuary

4 Conclusion

The distribution pattern of chlorophyll-a is the same as the distribution pattern of phosphate, nitrate, salinity, and temperature.The distribution pattern of chlorophyll-a was concentrated at station 12, the right in front of the branching estuary of the Wulan River, with a value of 12.296 $\mu g.L^{-1}$.Based on the observation of the distribution pattern, it can be concluded that the phosphate, nitrate, salinity, and temperature content can affect chlorophyll-a, which represents primary productivity in the Delta Wulan Estuary.

Acknowledgment

This research is supported by The Faculty of Fisheries and Marine Sciences, Diponegoro University, with contract number 26/UN7.F10/PP/III/2023. We want to thank you very much for the team laboratory in the Marine Biology Laboratory.

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