Distribution Pattern of Chlorophyll-a in the Delta Wulan Waters, Demak Regency, Central Java, Indonesia

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Abstract

The Delta Wulan waters are categorized as estuarine waters, which are greatly influenced by the sedimentation from the Wulan River and Serang River. Besides, the Delta Wulan Waters are vulnerable to the impact of pollution from anthropogenic waste. This research aims to examine the distribution pattern of chlorophyll-a and water quality parameters in the Delta Wulan Waters. Samplings were carried out at 12 stations, which were located in the middle of the Delta Wulan waters. One liter of water samples was taken using a Niskin bottle. The water quality measurements were carried out in situ. The research revealed that the highest chlorophyll-a value was found at Station 11 (2.94 ug/L) in November 2023, and the lowest chlorophyll-a value was also found in November 2023 at Station 6 (0.01 ug/L). Meanwhile, in August 2023, the chlorophyll-a value was in the range of 0.53–8.02 µg/L. The observations in August and November showed that the distribution pattern of chlorophyll-a was regular for stations 1 to 12 (dispersion index value < 1)

Keywords: Chlorophyll-a, Dispersion Index, Water Quality

INTRODUCTION

The Delta Wulan Waters is in front of the estuary of the Wulan River, which is located in Wedung Districts, Demak Regency, Central Java, Indonesia. The Delta Wulan Waters are strongly influenced by water masses from the Old Wulan River, New Wulan River, and Serang River (Fadlillah *et al*., 2018). The large human activities, which include rice fields and aquaculture upstream of the estuary, impact anthropogenic pollution (Yamani *et al*., 2011) as well as relatively high sedimentation rates (Purnomo *et al*., 2016). This certainly has quite a heavy impact on the waters of the Wulan Delta (Fadlillah *et al*., 2018), i.e., high nutrient concentrations which could be measured by the level of chlorophyll-a. The chlorophyll-a content in water can encourage the diversity of marine organisms.

The waters of the Delta Wulan Waters have a mangrove ecosystem with a sandy mud substrate. The coastal community who lived around the Delta Wulan made a living as fishermen catching fish, shrimp, and demersal organisms such as gastropods and shellfish. There are abandoned ponds on the Wulan Delta that have been used for culturing blood cockles. Benthic and pelagic organisms rely on the phytoplankton in the waters. According to Garini *et al*. (2021) chlorophyll-a is one of oceanographic parameters used to indicate the abundance of phytoplankton in waters and has an essential role in the photosynthesis process. The distribution pattern and variability of Chlorophyll-a content in coastal waters is higher than in open sea waters due to the nutrient supply from the land (Winarso & Marine, 2014; Nuzapril *et al*., 2017). The highest nutrient supply will result in high chlorophyll-a content in coastal and estuary waters (Kartika *et al*., 2022).

The high human activity along the Wulan River will affect its water quality conditions. The Wulan River, which carries a lot of anthropogenic and agricultural wastes, will cause high nutrient values in the Wulan Delta waters, which in turn will result in high chlorophyll-a values (Kartika *et al*., 2022). The high chlorophyll-a content in a body of water reflects high primary productivity, positively impacting water productivity. The chlorophyll-a is always found in phytoplankton or microalgae to carry out the photosynthesis (Minsas, *et al*., 2013; Pei, *et al*., 2018).

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The supply of nutrients from the Wulan River upstream is affected by the season that also influences the water quality, such as dissolved oxygen, pH, salinity, etc. Therefore, this research aims to determine the chlorophyll-a content during the east and west moonson.

MATERIAL AND METHOD

The research was carried out in the Wulan Delta waters (Figure 1). One liter of seawater was taken at 12 stations using a Niskin Bottle on 1st August 2023 to represent the dry season (East Moonson) with no rainfall and 19 November 2023 to represent the wet season (West Moonson), which is the rainy season with a lot of rainfall and a large supply of water from the Wulan River.

The chlorophyll was extracted with standard ethanol extraction and pre- and post-acidification measurements (Lorenzen 1967). A UV/VIS spectrophotometer with a 1 nm spectral bandwidth and optically matched 4 cm micro-cuvettes are used in the present work. Chlorophyll-a was measured using the spectrophotometer and calculated using the formula of Dere *et al*., 1998.

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

Note: E = the volume of acetone used for the extraction (10 mL); V = the volume of water filtered (1000 mL); L = the cell path length (cm); A665a = Absorption at 665 nm after acidification; A663 b = Absorption at 663 nm before acidification.

At the same time as seawater sampling, the measurement of sea surface temperature, pH, salinity, dissolved oxygen (DO), TSS (Total Suspended Solid), conductivity, and brightness was conducted using a thermometer, pH meter, refractometer, DO-meter, conductivity meter, and secchi-disc at 12 sampling stations. The nitrate and phosphate concentration of seawater was also analyzed.

Data Analyzes

The calculation of the Dispersion index followed the formulation of Lane *et al*., 2023. Wilcoxon's test is employed to determine the difference in chlorophyll-a content between August and November 2023. Multiple Regression was applied to study the relationship between chlorophyll-a and the value of water quality parameters such as pH, phosphate, nitrate, temperature, salinity, DO, pH, and brightness

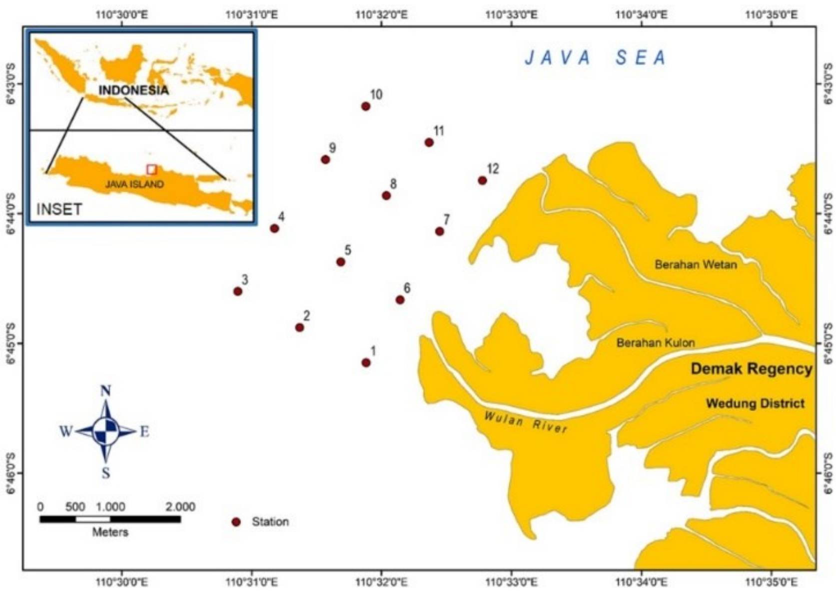

Figure 1. The Map of Sampling Location at Wulan Delta Waters (Source: Final Report of Hibah FPIK, 2023)

RESULT AND DISCUSSION

Based on observations in August 2023, the highest chlorophyll-a content was found at Station 2 (8.02 μg/L), and the lowest was at Station 6 (0.53 μg/L). During observations in August, with average of 5.82 μg/L. This was higher than November (1.38 μg/L) (Figure 2). Additionally, in November 2023, the highest chlorophyll-a content occurred at Station 11 (2.94 μg/L), and the lowest chlorophyll-a content was at station 6 (0.01 μg/L).

There is a significant difference in the Chlorophyll-a content between August and November 2023 (T= 53.29, P>0.05, Wilcoxon's test for the matched test). The chlorophyll-a content in August and November are relatively high, this is because the Wulan Delta are coastal waters. Coastal waters generally have higher nutrient content than open sea waters (Irawati, 2014). The highest nutrient content in coastal waters is due to the supply of nutrients from river estuaries and upstream region.

The Wulan River is divided into 2 parts, i.e., the Old Wulan and the New Wulan River. The New Wulan River was formed as an impact of dredging, while the Old Wulan River has occurred since a long time ago. The high human activities (rice fields, brackishwater fisheries, freshwater fish ponds, and other activities) on the banks cause the Wulan River to carry a load of organic and inorganic materials into Wulan Delta waters. This condition will influence the water quality. Based on this research, the DO value measured in August was in the range of 6.4–8.2 mg/L, while in November was 3.2–8.3 mg/L. The average DO value of August 2023 (7.38 mg/L) was higher than in November (4.98 mg/L). The average concentration value in August and November is still close to the water quality standards (WQSs). Based on Water Quality Standards (WQSs) for Estuaries and Aquaculture according to the Decree of The Minister of State for The Environment of the Republic of Indonesia Number 51/MENKLH/2004 for marine biotic, the DO concentration value is 5 mg/L. The highest average value of DO concentration in August (7.38 mg/L) shows that the waters of the Wulan Delta gave good support for phytoplankton growth, which is also indicated by the high content of Chlorophyll-a on the surface in August (5.82 ± 2.19 μg/L). While in November, observations were lower than in August, in which the average value of DO concentration was 4.98 ± 1.59 mg/L, and the average value of chlorophyll-a content was 1.38 ± 0.97 mg/L. The low DO concentration in the water is due to aquatic organisms that use oxygen for respiration (Sany *et al*., 2014). Low oxygen concentration values in water can also be caused by the process of organic materials breaking down into inorganic compounds. On the other hand, the high DO concentration value is due to the photosynthesis process in the waters, which can be seen from the high abundance of phytoplankton, represented by the high content of chlorophyll-a.

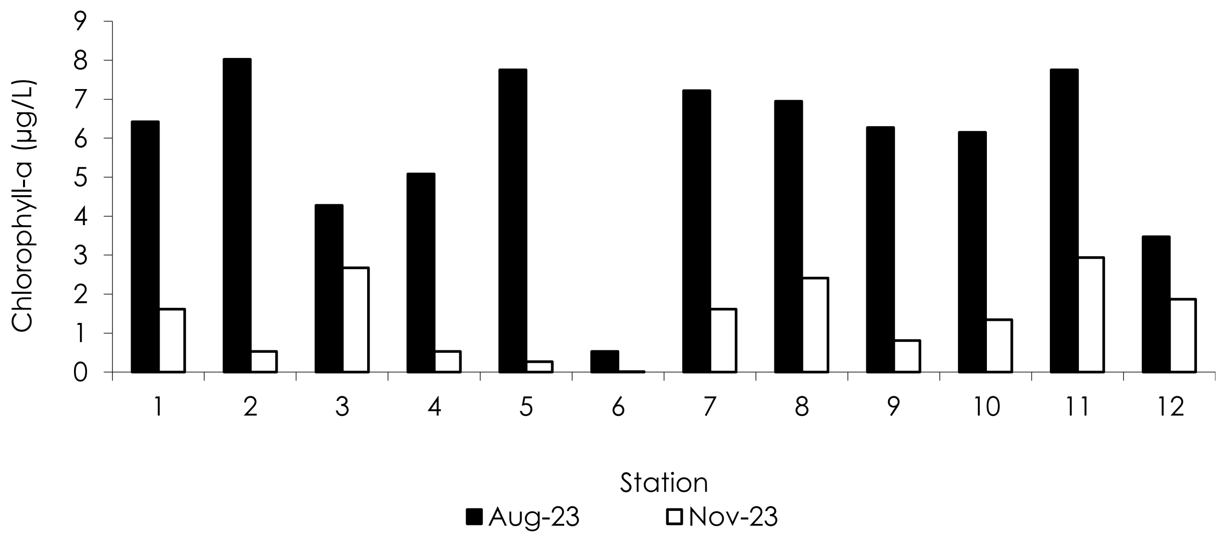

Figure 2. Chlorophyll-a Content at station 1 till 12 in the Delta Wulan Waters

The high average value of chlorophyll-a in August (5.82 µg/L) was also followed by the high average Phosphate concentration (0.15 ± 0.09 mg/L) and nitrate (3 ± 2.13 mg/L) (Table 1). Meanwhile, in November 2023, the average value of chlorophyll-a was 1.38 ± 0.97 µg/L, followed by a low average Phosphate breaking (0.07 ± 0.07 mg/L) and nitrate breaking of 1.67 ± 0.78 mg/L (Table 1).

The average pH value in August (8.18 ± 0.61) is almost the same as in November (8.07 ± 0.15) (Table 1), which indicates alkaline properties. This explains the smoothly running conversion process of organic material into inorganic in these waters. Zang *et al.* (2011) stated that there was a positive correlation between chlorophyll-a, DO, and pH if the chlorophyll-a concentration was higher than 10 µg/L, and vice versa.

Based on measurements in August 2023, the average TSS value was 24.5 ± 0.15 mg/L higher than the value in November (20.83 ± 7.08 mg/L) (Table 1). The high TSS value in August indicates the high phytoplankton abundance, reflected in the high average value of chlorophyll-a (5.82 ± 2.19 µg/L). The TSS values were the same as a result of Fadlillah *et al*. (2017) in 2016, i.e., 22.4 mg/L. The magnitude of the TSS value in estuarine waters greatly depends on the magnitude of the water discharge from the river into sea waters (Gray *et al*., 2014). The greater the water discharge from the river, the greater the seas' TSS value and turbidity level. The TSS (Total Suspended Solid) value will increase turbidity and disrupt photosynthesis (Effendi, 2003).

The average salinity value in August 2023 was 30.91±0.77 ppt higher than in November (26.40 ± 7.08 ppt). This is in line with measurements in May and August 2020, with a range of 29.25–33.50 ppt (Widianingsih *et al*., 2021). The higher salinity value in a body of water positively correlates with calcium, chloride, and magnesium. Chlorophyll-a content, total nitrogen, and total phosphate positively correlate with salinity content (Ali *et al*., 2004; Al-Taee, 2018; Kartika *et al*., 2022)).

The research result of August 2023 showed that the phosphate, nitrate, temperature, salinity, DO, pH and brightness influenced the chlorophyll-a content (multiple regression analysis; R Square value of 0.855 or 85.5%). So do the results of observations in November 2023 (multiple regression analysis; R square value of 0.638 or 63.8%). The influence of all water quality parameters on the chlorophyll-a content is higher in August compared to November 2023, this shows that the water conditions of the Wulan Delta in August 2023 are better than in November 2023. The work of Maradhy *et al*. (2021) in Tarakan waters showed the same result. There is a significant relationship between nitrate and chlorophyll-a content but no relationship with phosphate. Meanwhile, in the Socah Estuary Waters, Bangkalan Regency, Madura, there is a correlation between nutrient and chlorophyll-a content (Kartika et al., 2022). According to Zang *et al*. (2011), the chlorophyll-a value of more than 10 µg/L shows a positive correlation with the pH value and DO content in a body of water, and vice versa

Table 1. Water Quality in the Delta Wulan Waters

Parameter	Average Value ± SDev	
	August 2023	November 2023
Phosphate (mg/L)	0.15 ± 0.09	0.07 ± 0.07
Nitrate (mg/L)	3 ± 2.13	1.67 ± 0.78
Brightness (m)	0.83 ± 0.33	1.43 ± 0.46
Temperature (°C)	28.09 ± 0.48	29.29 ± 3.86
Salinity (ppt)	30.91 ± 0.77	26.4 ± 8.74
DO (mg/L)	7.38 ± 0.55	4.98 ± 1.59
pH	8.18 ± 0.61	8.07 ± 0.15
TSS	24.5 ± 0.15	20.83 ± 7.08
Depth (m)	6.58 ± 2.72	5.73 ± 2.29

CONCLUSION

The average value of chlorophyll-a in August observations was higher (5.82 ± 2.19Bµg/L) than in November (1.38 ± 0.97 µg/L). The high average value of chlorophyll-a in August was also followed by the high average value of phosphate concentration (0.15 ± 0.09 mg/L), Nitrate (3 ± 2.13 mg/L), DO concentration (7.38 ± 0.55 mg/L), and the TSS value (24.5 ± 0.15 mg/L). The statistical analysis shows a significant difference between chlorophyll-a in August and November. The water quality parameters, such as phosphate, nitrate, temperature, salinity, DO, pH, and brightness, influence the chlorophyll-a content (multiple regression analysis, R square in August is 0.855, and in November, the R square value equal to 0.638)

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REFERENCES

Ali, Y., Aslam, Z., Ashraf, M.Y., & Tahir, G.R. (2004). Effect of salinity on chlorophyll concentration, leaf area, yield, and yield components of rice genotypes grown under saline environment. *International Journal of Environmental Science & Technology*, *1*, 221-225.

Al-Taee, I.A. (2018). Salinity affects chlorophyll significantly. *Plant Archives*, *18*(1), 723-726.

Dere, Ş., GÜNEŞ, T., & Sivaci, R. (1998). Spectrophotometric determination of chlorophyll-A, B and total carotenoid contents of some algae species using different solvents. *Turkish Journal of Botany*, *22*(1), 13-18.

Efendi, H. (2003). Telaah Kualitas Air. *Yogyakarta: Kanisius*.

Handayani, T., Sabariah, V., & Hambuako, R. R. (2017). Species composition of sea cucumber (Holothuroidea) in the Kapisawar Village-Meos Manswar District Raja Ampat Regency. *Jurnal Perikanan Universitas Gadjah Mada*, *19*(1), 45-51.

Fadlillah, L.N., Widyastuti, M., & Marfai, M.A. (2018). The impact of human activities in the Wulan Delta Estuary, Indonesia. *IOP Conference Series: Earth and Environmental Science,* 148(1), p. 012032. doi:10.1088/1755-1315/148/1/012032

Gray, A.B., Warrick, J.A., Pasternack, G.B., Watson, E.B., & Goñi, M.A. (2014). Suspended sediment behavior in a coastal dry-summer subtropical catchment: effects of hydrologic preconditions. *Geomorphology*, 214, 485-501.

Irawati, N. (2014). Pendugaan kesuburan perairan berdasarkan sebaran nutrien dan klorofil-a di Teluk Kendari Sulawesi Tenggara. *Aquasains*, *3*(1), 193-200.

Kartika, A.G.D., Jayanthi, O.W., Nuzula, N.I., Syafullah., M., & Siswanto A.D. (2022). Nutrients and chlorophyll-a concentration in Socah Estuary receiving Shrimp pond waste, Bangkalan Regency. *IOP Conference Series: Earth and Environmental Sciences*. 1251(1), 012010. doi: 10.1088/1755-1315/1251/1/012010.

Lane, D.M., Scott, D., Hebl, M., Guerra, R., Osherson, D., & Zimmer, H. (2023). Introduction Statistic. Rice University; University of Houston, Downtown Campus. 699pp.

Lorenzen, C.J. (1967). Determination of chlorophyll and phaeo-pigment: Spectophotometric Equations. *Limnology and Oceanography,* 12 (2), 343-346.

Pei, S., Laws, E.A., Zhang, H., Ye, S., Kemper, M.T., Yuan, H., Xu, G., Yang, S., Liu, H. & Zhu, Y. (2018). Study on chemical hydrography, chlorophyll-a and primary productivity in Liaodong Bay, China. *Estuarine, Coastal and Shelf Science*, 202, 03-113.

Purnomo, S.N., Widiyanto, W., Astritia, T.& Pratiwi, T.P. (2016). Analisis sedimentasi dan morfologi Muara Sungai Ijo. *Prosiding Konferensi National Teknik Sipil 10. Unika Atma Jaya. Yogyakarta*. Hal: 436-446.

Maradhy, E., Nazriel, R.S., Sutjahjo, S.H., Rusli, M.S., Widiatmaka, & Sondita, M.F.A. (2022). The relationship of P and N Nutrient content with Chlorophyll-a Concentration in Tarakan Island

Water. *IOP Conference Series: Earth and Environmental Science,* 1083(1), 012077. doi: 10.1088/1755-1315/1083/1/012077

Minsas, S., Zakaria, I.J. & Nurdin, J. (2013). Komposisi dan kandungan Klorofil-a Fitoplankton pada musim Timur dan Musim Barat di Estuary Peniti, Kalimantan Barat. *Jurnal Prosiding Semirata*. 1(2), 381-386.

Nuzapril, M., Susilo, S.B., & Panjaitan, J.P. (2017). Relationship between chlorophyll-a concentration with primary productivity rate using Landsat 8 imagery. *Jurnal Teknologi Perikanan dan Kelautan*, 8(1), 105-114. doi: 10.24319/jtpk.8.105-114.

Sany, S.BT., Hashim, R., Rezayi, M., Salleh, A., & Safari, O. (2014). A review of strategies to monitor water and sediment quality for a sustainability assessment of marine environment. *Environmental Science and Pollution Research*, *21*, 813-833.

Yamani, M., Goorabi, A., & Dowlati, J. (2011). The effect of human activities on river bank stability (case study). *American Journal of Environmental Sciences*, *7*(3), 244-247.

Widianingsih, W., Nuraeni, R.A.T., Hartati, R., Endrawati, H., Sugianto, D.N., & Mahendrajaya, R.T. (2021). Water quality in the ecosystem of sea cucumber Acaudina sp. in the Delta Wulan Waters, Central of Java, Indonesia. In *IOP Conference Series: Earth and Environmental Science,* 744(1), p. 012097.

Winarso, G., & Marini, Y. (2014). MODIS standard (OC3) chlorophyll-a algorithm evaluation in Indonesian seas. *International Journal of Remote Sensing and Earth Sciences*, *11*(1), 11-20.

Zang, C., Huang, S., Wu, M., Du, S., Scholz, M., Gao, F., Lin, C., Guo, Y. & Dong, Y. (2011). Comparation of relationship between pH, dissolved oxygen and chlorophyll-a for Aquaculture and non-aquaculture waters. *Water, Air & Soil Pollution*, 219, 157-174.