SPATIAL DISTRIBUTION OF CHLOROPHYLL-A AND NUTRIENTS IN THE TENGAH ISLAND, KARIMUNJAWA INDONESIA

DISTRIBUSI SPASIAL KLOROFIL-A DAN NUTRIEN DI PULAU TENGAH, KARIMUN JAWA INDONESIA

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ABSTRACT: Tengah Island is located between Sintok Island and Cilik Island in Karimunjawa, Jepara Regency, Central Java. Tengah Island is one of the zones for the use of marine tourism, which has the allure of attractive spots for snorkeling and diving for tourists. Coral reefs require chlorophyll-a, which is in this case produced by zooxanthellae, as a photosynthetic pigment. The chlorophyll-a concentration is influenced by many factors, including nutrients and environmental parameters. This study aims to see the spatial distribution of chlorophyll-a on Tengah Island and its relationship to nutrients, including ammonium, phosphate, and nitrate, as well as environmental parameters, namely Total Suspended Solid (TSS), salinity, pH, Dissolve Oxygen (DO), temperature, and brightness. Chlorophyll-a is analyzed using the APHA standard (2005), while nutrient analyses for ammonium, nitrate, and phosphate employ the UV-Vis spectrophotometer and Nessler reagent, the APHA 4500-No.3-B (2017), and the APHA 4500-P B, C (2017), respectively. TSS is obtained from Sentinel-2A data processing. The correlation between each dataset was carried out by a method of statistical analysis called Principal Component Analysis (PCA). The results showed that chlorophyll-a had a close relationship with ammonium (r=0.826), brightness (r=0.492), and TSS (r=-0.979). The highest chlorophyll-a concentration of 1,063 µg/L was obtained at Station 1, which is the jetty area and the closest to the mainland. This finding is supported by maximum ammonium, sourced from domestic waste and microbial activity, and good brightness, required by chlorophyll-a for photosynthesis processes.
Keywords: chlorophyll-a, nutrients, PCA Analysis, Tengah Island, water quality

ABSTRAK*: Pulau Tengah terletak di tengah antara Pulau Sintok dan Pulau Cilik di Karimunjawa, Kabupaten Jepara, Jawa Tengah. Pulau Tengah merupakan salah satu zona pemanfaatan wisata bahari, yang memiliki daya pikat spot menarik untuk snorkling dan menyelam bagi wisatawan. Terumbu karang membutuhkan klorofil-a sebagai pigmen fotosintesis oleh zooxanthellae. Konsentrasi klorofil-a dipengaruhi banyak faktor diantaranya yaitu nutrien dan parameter lingkungan. Penelitian ini bertujuan untuk melihat sebaran spasial klorofil-a di Pulau Tengah dan keterkaitannya dengan nutrien meliputi ammonium, fosfat dan nitrat serta parameter lingkungan yaitu Material Padatan Tersuspensi (MPT), salinitas, pH, Oksigen Terlarut (DO), suhu dan kecerahan, Metode analisa klorofil-a menggunakan standard APHA (2005), ammonia menggunakan spektrofotometer UV-Vis dan pereaksi Nesler, nitrat menggunakan APHA 4500-No.3- B (2017), dan fosfat menggunakan APHA 4500-P B, C (2017). Selanjutnya untuk TSS diperoleh dari pengolahan data satelit Sentinel-2A. Selain itu,* pengolahan *data korelasi menggunakan Analisis Komponen (PCA). Hasil penelitian menunjukkan klorofil-a memiliki keterkaitan yang erat dengan ammonium (r=0,826), kecerahan (r=0,492), dan MPT (r=-0.979). Klorofil-a tertinggi diperoleh di stasiun 1 sebesar 1,063 µg/L yang merupakan area dermaga dan terdekat dengan daratan. Temuan ini didukung bahwa ammonium bersumber dari limbah domestik dan aktifitas mikroba serta klorofil-a membutuhkan kecerahan yang baik untuk proses fotosintensis.*
Kata Kunci: *analisa PCA, klorofil-a, kualitas perairan, nutrien, Pulau Tengah*

INTRODUCTION

Tengah Island is located on the east side of the Karimunjawa National Park (TNKJ), which is bordered by Karimunjawa Island on the west side, the high seas on the east side, Sintok Island on the north side, and Cilik Island on the south side (Figure 1). Tengah Island is part of the marine utilization zone located in TNKJ, with the attractiveness offered is the beauty of coral reefs with high coral density and a variety of coral species (Wungo et al., 2020). Furthermore, there is a resort and jetty with complete facilities to pamper the tourist who will visit Tengah Island (Umardiono, 2011).

Chlorophyll-a (chl-a) is a green pigment found in plants (macro and micro-organism) that allows the process of photosynthesis using sunlight as the main energy to produce organic compounds from simple molecules. As a consequence, chl-a is used as a measure of phytoplankton biomass in the waters. Moreover, chl-a is also used as an indicator of the water fertility level, water quality, and indicator of nutrient availability (Trevor et al., 1998). Coral reefs are animals of polyp species that have mutualism symbiosis with algae, in this case, zooxanthellae which contain chlorophyll-a and -c pigments. The content of chl-a in these zooxanthellae carries out the photosynthesis process, which is very much needed for its survival (Sayekti et al., 2017).

The concentration of chl-a in the waters is influenced by many factors, such as nutrient inputs namely ammonia, phosphate, and nitrate (Inayati & Farid, 2020; Qiu et al., 2021), and environmental parameters specifically as Total Suspended Solid (TSS), salinity, pH, Dissolved Oxygen (DO), temperature and brightness (Zulhaniarta et al., 2015; Moira et al., 2020). Besides, the sediment also plays a significant effect to chl-a nutrients since the sediment experience erosion, transportation, and deposition on a temporal and spatial scale so it will affect the physical conditions of the surrounding environment (Nugroho & Basit, 2014). This process indirectly triggers sediment as a place for trapping nutrients (Rizal et al., 2017). Generally, the sediment type in Batu Putih, Karimunjawa, which is closed and located in the left side of Tengah Island is dominated by sand, then followed by silt and clay (Gamellia et al., 2019).

In case the input of nutrients exceeds the equilibrium condition, it will have a serious impact on the occurrence of eutrophication leads to algae blooms, which disrupts

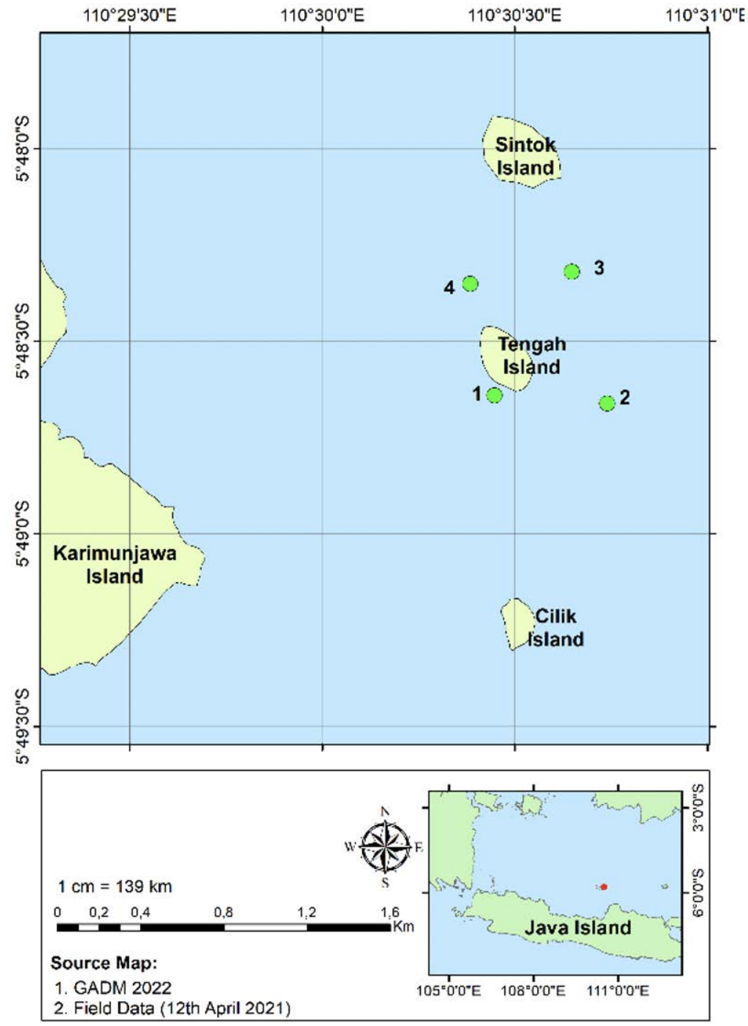

Figure 1. Research area nearby Tengah Island (red dot in the inset), green circles with numbers are the observation stations

marine aesthetics, and decreases DO hence affects the survival of coral reefs. Previous studies according chl-a and nutrients had been conducted in TNKJ such as in Menjangan Kecil Island (Pangaribuan et al*.,* 2013), Karimunjawa Island (Isnaeni et al*.,* 2015), Sintok Island (Alhaq et al*.,* 2021), Seruni Island (Widiaratih et al*.,* 2022), and Menjangan Besar Island (Nursalim et al*.,* 2022). Due to limited study concerning chl-a, nutrients and TSS in Tengah Island lead this research to determine the spatial distribution of chl-a in the Tengah Island, Karimunjawa and its relationship with nutrients (ammonium, phosphate and nitrate) and environmental parameters (TSS, salinity, pH, DO, brightness and temperature). Moreover, the dependence of coral reefs on chl-a, nutrients and TSS are very substantial, due to the effect resulting from tourism activity since there are jetties and resorts on Tengah Island which generates domestic waste. Furthermore, TSS contributes to turbidity by limiting light penetration for photosynthesis and visibility in waters (Rizka et al*.,* 2020).

METHODS AND MATERIAL

There were 4 observation stations purposely taken around to know the spatial distribution in Tengah Island on 12th April 2021. Station 1 is located in the jetty area, very close to the mainland of Tengah Island. While Station 2 represents the area near Cilik Island and high seas in the southeast area. Station 3 reflects area near Sintok Island and high sea in the northeast area. Moreover, Station 4 represents area near Karimunjawa and high seas in the northwest.

For each station, field data was taken of 2L surface water samples using a Nansen bottle. Furthermore, sample waters were put in dark bottles and saved in a cool box. Hereinafter the samples water was put in the freezer (Nufus et al*.,* 2017), then processed further in the laboratory. Especially for chl-a, the water samples was filtered by cellulose filtering paper Millipore 0.45 µm using a vacuum pump. These filter paper then dissolved in 10 ml acetone and saved in the freezer for at least 16 hours. Hereinafter, then undertook the centrifuge ± 10 minutes for each sample, then carried out the spectrometry to be read in trichromatic wavelength (664, 648 and 630 nm). Chl-a data processing using the APHA standard (2005), while nutrient processing for ammonia using SNI 06-6989.30 (2005), nitrate using APHA 4500-No.3-B (2017), and phosphate using APHA 4500-P B, C (2017). As for environmental parameters, were analyzed using several equipments such as salinity using a refractor, pH using a pH-meter, brightness using a secchi disk, Dissolved Oxygen (DO) and sea surface temperature using a Water Quality Checker.

Moreover, TSS data was obtained from satellite processing of Sentinel-2A level 2, and was downloaded from the European Space Agency (ESA) via the Copernicus Open Access Hub website (https://scihub.copernicus.eu/). The imaginary was accessed on 10th November 2022. Sentinel-2A has a spatial resolution of 10m, and a temporal resolution of 5 days. The formula calculation of TSS is obtained from Laili et al*,* (2015) as:

$$TSS\ (mgL^{-1}) = 31.420\left(\frac{logRrs(\lambda 2)}{logRrs(\lambda 4)}\right) - 12.719 \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Rrs(λ2): remote sensing reflectance of band 2
Rrs(λ4): remote sensing reflectance of band 4.

Furthermore, from this imaginary, the TSS data was extracted from the pixel reading of Sentinel-2A.

Statistical analysis for describing the relationship between chl-a to nutrients and another environmental parameter such as TSS, salinity, pH, DO, brightness and temperature used the Pearson's and Principal Component Analysis (PCA) approach. This PCA method is to simplify data to a new coordinate system that has a maximum variance, without significantly reducing the characteristics of the data (Firliana et al*.,* 2015). The advantage of this method is to minimize multicollinearity problems without having to exclude the independent variables involved in collinear relationships. In addition, using the PCA method can determine the dominant factors that affect a parameter (Rahmawati, 2014).

RESULTS

The result of the concentration measurement of chl-a, nutrients, and environmental parameters in Tengah Island is seen in Table 1. The range of chl-a concentrations is 1.1063-0.772 µg/L with an average of 0.861 µg/L. The highest chl-a is found at Station 1 where the jetty area exists and is the closest station to the mainland. This is in line with Schalles (2016) who demonstrated that the farther from the coastal, the smaller chl-a value obtained. Generally, the concentration of chl-a in Tengah Island is still in a suitable range of chl-a for coral reef habitat, which the value is not in the eutrophic condition. The eutrophic condition of chl-a based on Ignatiades et al. (1992), is between 1.16 - 1.84 g/L.

The results of the concentration range for nutrients specifically ammonia, nitrate and phosphate, are 0.088-0.111 µg/L, 0.005-0.010 µg/L, and 0.001 µg/L respectively. In general, the smallest value is found for phosphate in Tengah Island, this is due to the existing sources of phosphate do not come from domestic and industrial waste, but from natural sources, namely diffusion from sediment (Widiaratih et al*.,* 2022). Ammonia concentration shows the same pattern as chl-a, the highest concentration is discovered at Station 1, which is the jetty area and the closest point to the land. This finding is emphasized by the input of domestic waste, and microbial activity in Tengah Island derived from tourist resorts and jetty. However, the ammonia concentration achieved is still below the seawater quality standard < 0.3 mg/L (KepmenLH 51/2004).

Furthermore, the concentration of nitrate obtained is smaller than ammonia, it corresponds to the Nitrogen

Cycle with the phase sequence transformation of ammonium-nitrite-nitrate (Patey et al., 2008). The measurement of nitrite concentration was not carried out in this research, considering the TNKJ waters have clear sea water and good brightness, so it would be a very small amount of nitrite found. Besides, this is confirmed by the results of high ammonium concentrations, because the transformation process from the nitrogen cycle has not occurred, so any ammonium in the sea will be transformed into the final form of nitrate, therefore the nitrate concentration found in Tengah Island is to be lower than ammonium (Meirinawati & Fitriya, 2018). Analysis of DIN (ammonia, nitrate, and phosphate) is shown in Table 1. Because we didn't analyze nitrite calculation, the DIN is only the sum of ammonium and nitrate. Geider and Roche (2002) have shown that there is the term Redfield ratio in aquatic biogeochemistry, a concept that refers to the relationship between the composition of organisms and water chemistry. The Redfield ratio is based on the statement of R.H. Fleming's (1940) who stated that the C:N:P content of plankton is 106:16:1. Redfield N:P as 16:1 is often used as a benchmark to distinguish the limiting factor between N and or P in water (Pello et al., 2014; Wydiastuti et al., 2015). From Table 1, the Redfield (N/P) is obtained higher than 16, which means that P is a limiting factor.

The results of the environmental parameter values generally show that Tengah Island is still in preferable condition and supports coral reef ecosystems. The results of the range of values for TSS, salinity, pH, DO, Brightness, and temperature is 4.19×10^3–10.25×10^3 µg/L, 27-30‰, 7.53-7.86, 5.32-6.55 µg/L, 98-100%, 29.7-30.9^{0}C respectively. According to Ompi et al. (2019), a suitable salinity range for coral reefs is 30-35‰. Tengah Island has a salinity range of 27-30‰, and only station 4 has ideal conditions for coral reefs. Furthermore, according to Juliani and Rahmatsyah (2011), the pH value of seawater quality standards for marine tourism is around 7-8.5, and the pH value in Tengah Island is still in the range of 7.53-7.86, so it is suitable for coral reefs. For DO value, according to Sumarno and Muryanto (2014), coral can grow in DO conditions with levels above 3.5 mg/L, while in Tengah Island it has a DO range of 5.32-6.55 mg/L, so it is convenient with coral reef habitats. The brightness is also very influential on the growth of coral reefs because there are zooxanthellae that need sunlight to carry out the photosynthesis process (Sayekti et al., 2017). This indicates that Tengah Island has a very great brightness. While for TSS, due to seawater quality standards (Permen LH No. 51/2004) stated that the Total Suspended Solids (TSS) permitted for the growth of coral reefs is 20 mg/L. Since the TSS range in Tengah Island is below the seawater quality standard (< 20 mg/L), it is still in ideal condition for coral reef habitat growth optimally.

Correlation results using Pearson's approach for chl-a, nutrients and environmental parameters are demonstrated in Table 2. In general, chl-a has a close relationship with ammonium (r=0.826). This has a pattern that the higher chl-a, the higher ammonia concentration found, this is in line with Riley and Chester (1971) and Chen (2007) which state that high ammonium is needed for metabolic processes, physiological processes and biochemical reactions by marine organisms. Furthermore, chl-a has a moderate but negative relationship with nitrate (r=-410) and phosphate (r=-558).

Correlation between chl-a with environmental parameters indicate that chl-a has a high negative correlation with TSS (r=-0.979). Chl-a, shows a moderate and positive relationship with brightness, this is because

Table 1. The Concentration of chl-a, nutrient and environment parameters in Tengah Island, TNKJ

Station	Salinity (‰)	PH	DO (µg/L)	Brightness (%)	Temperature (⁰C)	Chlorophyll-a (µg/L)	Ammonium (µg/L)	Nitrate (µg/L)	Phosphate (µg/L)	TSS (µg/L)	DIN:DIP
Tengah 1	27	7.63	5.82×10^3	100	30.7	1.063	0.111	0.005	0.001	4.19×10^3	116.71
Tengah 2	27	7.86	5.42×10^3	98	30.6	0.780	0.099	0.010	0.001	10.25×10^3	102.72
Tengah 3	27	7.53	5.32×10^3	99	29.7	0.829	0.088	0.005	0.001	9.95×10^3	87.60
Tengah 4	30	7.59	6.55×10^3	100	30.9	0.772	0.092	0.005	0.001	9.72×10^3	97.00

Table 2. Correlation of chl-a, nutrient and environment parameters in Tengah Island, TNKJ

		Salinity (‰)	pH	DO (µg/L)	Brightness (%)	Temperature (⁰C)	Chlorophyll-a (µg/L)	Ammonium (µg/L)	Nitrate (µg/L)	Phosphate (µg/L)	TSS (µg/L)	DIN:DIP
Correlation	Salinity (‰)	1.000	-0.289	0.922	0.522	0.533	-0.434	-0.348	-0.280	-0.495	0.274	-0.219
	pH	-0.289	1.000	-0.279	-0.706	0.388	-0.198	0.332	0.965	0.327	0.164	0.359
	DO (µg/L)	0.922	-0.279	1.000	0.731	0.727	-0.073	0.026	-0.372	-0.787	-0.109	0.152
	Brightness (%)	0.522	-0.706	0.731	1.000	0.344	0.492	0.244	-0.846	-0.900	-0.584	0.285
	Temperature (0C)	0.533	0.388	0.727	0.344	1.000	0.103	0.521	0.207	-0.688	-0.294	0.640
	Chlorophyll-a (µg/L	-0.434	-0.198	-0.073	0.492	0.103	1.000	0.826	-0.410	-0.558	-0.979	0.764
	Ammonium (µg/L)	-0.348	0.332	0.026	0.244	0.521	0.826	1.000	0.082	-0.548	-0.874	0.989
	Nitrate (µg/L)	-0.280	0.965	-0.372	-0.846	0.207	-0.410	0.082	1.000	0.540	0.402	0.103
	Phosphate (µg/L)	-0.495	0.327	-0.787	-0.900	-0.688	-0.558	-0.548	0.540	1.000	0.699	-0.616
	TSS(µg/L)	0.274	0.164	-0.109	-0.584	-0.294	-0.979	-0.874	0.402	0.699	1.000	-0.840
	DIN:DIP	-0.219	0.359	0.152	0.285	0.640	0.764	0.989	0.103	-0.616	-0.840	1.000

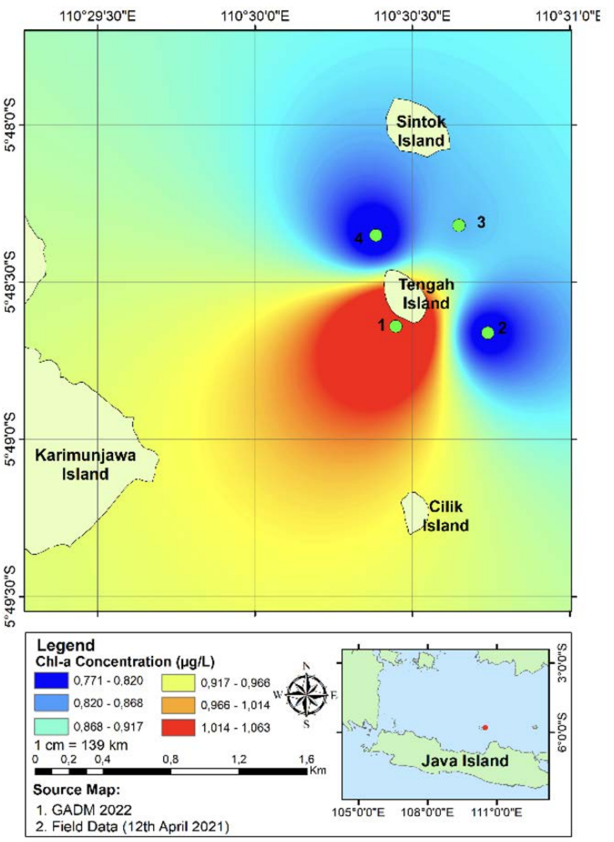

Figure 2. Distribution of chl-a (µg/L) from surface water in Tengah Island, TNKJ

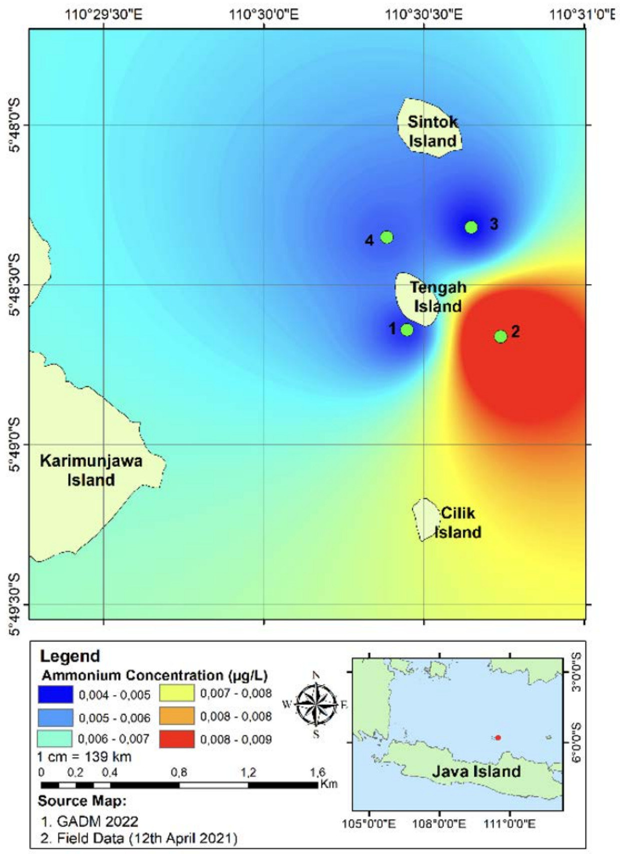

Figure 3. Distribution spatial of ammonium (µg/L) from surface water in Tengah Island, TNKJ

chl-a requires sunlight to carry out the photosynthesis process (Fauziah et al., 2019). While higher concentrations of TSS will result in turbidity which will inhibit the process of photosynthesis. Moreover, there is a significant correlation between nitrate and pH (r=0.965) with (α<0.05). This result is supported by the higher of pH value, the higher the amount of nitrate in the waters. This situation is in line with the research of Widiaratih et al. (2022) on Seruni Island, which showed similar pattern, when during the day the photosynthesis process runs optimally by marine biota that contains chl-a. Since there is sufficient solar intensity to produce O_2 it then has an effect on increasing the pH. This condition may decrease the DO value which is then used by marine biota to conduct the transformation phase of the nitrogen cycle from ammonia-nitrite and nitrate, leads to increase the amount of nitrate as the increasing of pH.

The spatial distribution pattern of chl-a and ammonium in Tengah Island is shown in Figures 2-3. In general, station 1 has maximum values for chl-a and ammonium, this is due to its position on the jetty and closest to the mainland which is a source of pollutants (domestic waste). The result corresponding from Bonnin et al. (2008), who argued that ammonia is produced from microbial activity, ammonia industry, coal processing and waste treatment such as domestic waste, agricultural waste, and waste from factories, especially nitrogen fertilizer factories.

The spatial pattern of phosphate is displayed in Figure 4. In general, stations 2 & 3 have maximum values for Phosphate. The concentration of phosphate was found to be the lowest value among other chemical compounds. According to Patty et al, (2015) natural phosphate sources come from weathering of mineral rocks and decomposition of organic matter and diffusion processes originating from sediments. This is supported by Station 3 located between Sintok Island and Tengah Island, which is dominated by coral and sand (Gamellia et al., 2019).

Furthermore, the spatial distribution pattern of nitrate in Tengah Island is presented in Figure 5. In general station 2 has a maximum value for nitrate. Chl-a requires nitrate compounds to be broken down to produce nitrogen (Hutagalung and Rozak, 1997). Moreover, nitrate is an essential nutrient to support the life of organisms in water (Muchtar, 2008). Nitrate has a close relationship (r=0.965) with a pH (α < 0.05). This is because the pH tends to increase during the day due to chemical and biological processes that occur in the form of photosynthesis from phytoplankton, microalgae, and aquatic plants that produce O_2.

The spatial distribution of TSS in Tengah Island is shown in Figure 6. The highest SST is found in station 2, which has similar pattern with nitrate. While the jetty area

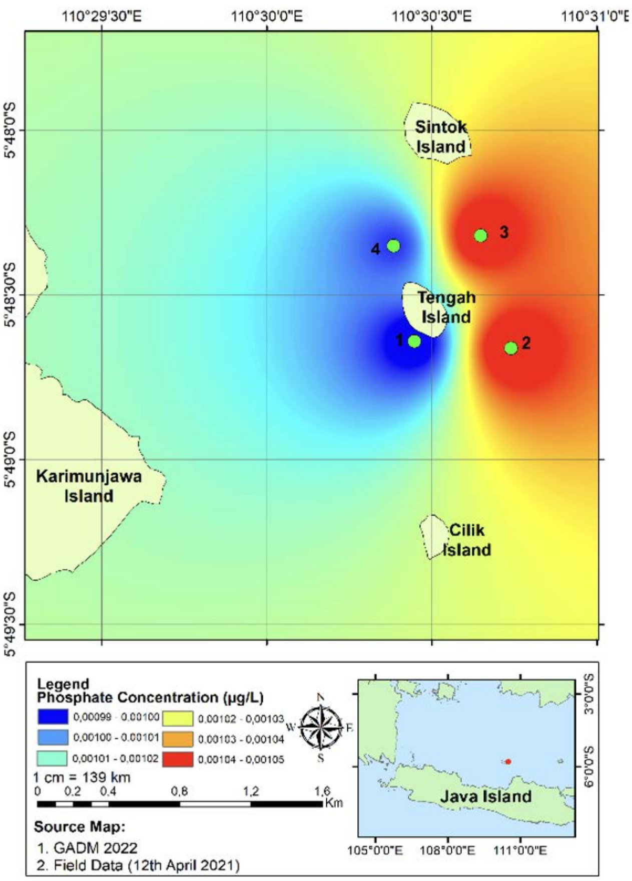

Figure 4. Distribution spatial of ammonium (µg/L) from surface water in Tengah Island, TNKJ

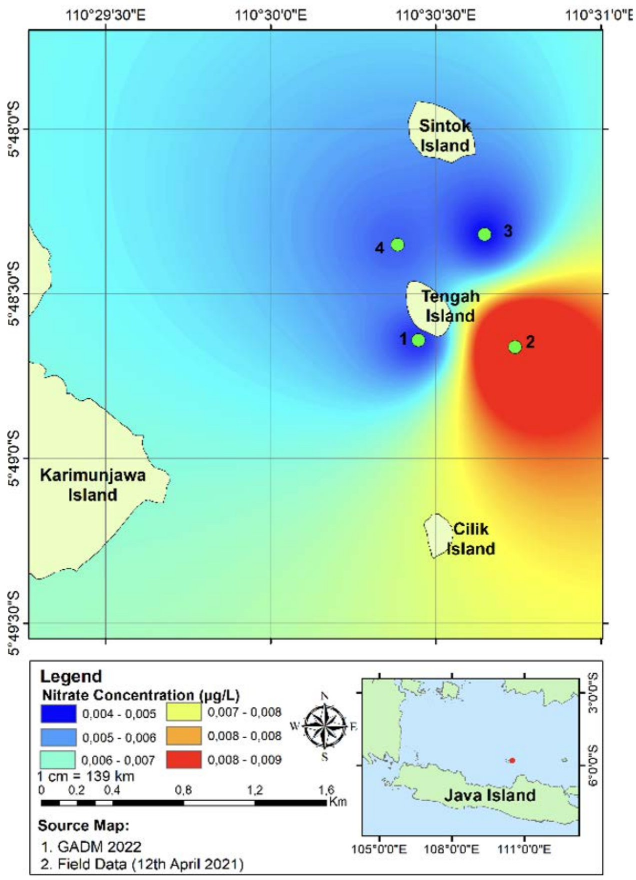

Figure 5. Distribution spatial of nitrate (µg/L) from surface water in Tengah Island, TNKJ

(station 1) shows the smallest TSS. This condition shows that the source of TSS comes from the high seas located to the east, indicates that the distribution of TSS is influenced by tides, currents, wind, and waves (Krisna et al*.,* 2012; Andini et al*.,* 2015; Siswanto, 2015). The higher wind, waves, currents, and tides lead to higher turbulence, hence higher TSS stirring. However, the TSS in Tengah Island is still in good condition. It can be seen from clear seawater.

DISCUSSIONS

Analysis of the correlation between chl-a, nutrients, and environmental parameters in this research by using PCA analysis. The advantages of this PCA analysis are that it can eliminate multicollinearity problems, the data are used for various types of research without reducing the number of original variables, and provide more accurate conclusions than other methods such as linear regression, etc (Soemartini, 2008). The basic principle of the PCA procedure is to simplify the observed variables by simplifying their dimensions. This process by eliminating the correlation between the independent variables through the transformation of the original independent variable to a new variable that is not correlated at all or commonly referred to as the principal component.

In PCA analysis there are 3 stages, are determining the main components to be arranged, criteria for

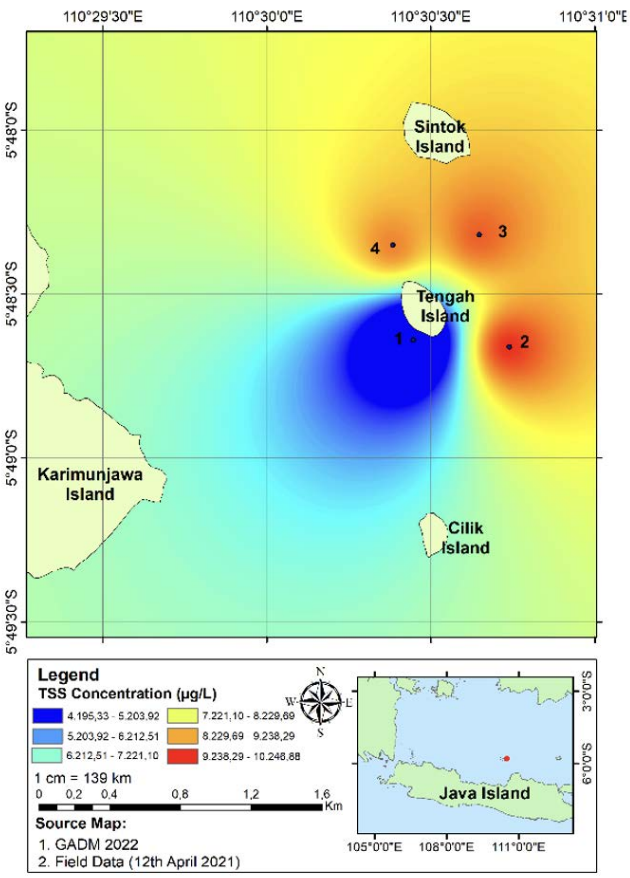

Figure 6. Distribution spatial of TSS (µg/L) from Sentinel-2A in Tengah Island, TNKJ

eigenvalues and criteria for a percentage of variance. In this study, there are 2 principal components, namely F1 and F2. Determining the composition of F1 and F2 can be seen from the value of the eigenvector which has a large and positive value. The F1 component is formed from the parameters such as brightness, temperature, chl-a, and ammonium, while the F2 component is formed from salinity, DO, and TSS (Table 3). The eigenvalues are shown in Table 4, where the eigenvalue of F1 is 5.17 and F2 is 3.44. According to Maindonal & John (2006), the required eigenvalue is at least >1 and is close to 1, so this value can explain the diversity of data on the main variable. Furthermore, the criteria for the percentage of variance, the results of PCA analysis show that with two axes it can explain 78.30% or more than 70% as required in the use of PCA (Ridho et al*.,* 2020), where the first axis contributes 47.00% and the second axis contributes 31.30% (Figure 6).

Table 3. Eigenvectors from principal component

Eigenvectors

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11
Salinity (‰)	0.112	0.432	-0.349	-0.058	-0.404	0.237	0.423	0.369	0.323	-0.010	-0.188
PH	-0.130	-0.378	-0.419	0.360	-0.273	-0.071	-0.356	0.311	-0.219	-0.265	-0.337
DO (µg/L)	0.264	0.331	-0.331	-0.231	0.181	-0.565	-0.438	-0.085	0.289	0.015	-0.152
Brightness (%)	0.376	0.265	0.107	0.128	0.314	-0.096	0.021	0.607	-0.463	-0.100	0.243
Temperature (0C)	0.262	-0.034	-0.518	0.179	0.283	0.016	0.431	-0.457	-0.359	0.059	-0.150
Chlorophyll-a (µg/L)	0.331	-0.251	0.302	0.003	-0.440	-0.602	0.381	-0.059	-0.021	-0.172	-0.042
Ammonium (µg/L)	0.310	-0.380	-0.046	-0.543	-0.087	0.156	-0.088	0.201	-0.188	0.550	-0.210
Nitrate (µg/L)	-0.235	-0.317	-0.393	0.050	0.083	-0.283	0.198	0.234	0.239	0.283	0.608
Phosphate (µg/L)	-0.425	-0.110	0.102	-0.234	0.480	-0.224	0.352	0.273	0.066	-0.129	-0.492
TSS (µg/L)	-0.378	0.221	-0.197	-0.549	-0.275	-0.112	0.007	-0.104	-0.505	-0.252	0.226
DIN:DIP	0.326	-0.346	-0.128	-0.334	0.189	0.284	0.003	0.004	0.262	-0.651	0.194

Table 4. Eigenvalue from principal component

Eigenanalysis of the Correlation Matrix

Eigenvalue	5.1670	3.4429	2.3900	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0000	-0.0000
Proportion	0.470	0.313	0.217	0.000	0.000	0.000	0.000	0.000	-0.000	-0.000
Cumulative	0.470	0.783	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Eigenvalue	-0.0000									
Proportion	-0.000									
Cumulative	1.000									

Parameters located in one quadrant can be interpreted that these parameters have closeness (Maindonal & John. 2006). Using PCA analysis, it can be seen the relationship between parameters. However, the value of the relationship between variables cannot be seen in PCA analysis. It can be seen through the Pearson correlation coefficient. The results of the PCA correlation between chl-a, nutrients, and environmental parameters are shown in Figure 7. The results of PCA analysis show that chl-a has a close relationship with ammonium, Redfield (N/P), and sea surface temperature. This is indicated by the 4 variables in the same quadrant. This is in line with the Pearson correlation value which shows a positive relationship. It supports with Person's correlation chl-a to ammonium, Redfield (N/P), and sea surface temperature are r=0.826, r=0.764, and r=0.103 respectively. The sea surface temperature also has a directly relationship to brightness. when it is brighter, the warmer sea surface temperature can occur in the water. It corroborated the Pearson's correlation chl-a to brightness which is higher than the chl-a correlation to the sea surface temperature by r= 0.492. From above discussion, the factors that affect chl-a in Tengah Island are nutrients and environmental parameters. specifically the most influential nutrient is ammonium proportional to Redfield (N/P). while the most influential environmental parameter is brightness and sea surface temperature.

Furthermore PCA analysis exhibits that nitrate and pH have a high correlation, revealed from the occurence of these parameters in one quadrant (Figure 7). This is also supported by the Pearson value which is very close r=0.965 and has a significant level of alpha <0.05. This related to the Nitrogen Cycle.

The distribution of observational variables of chl-a, nutrients and environmental parameters dispersed in 4 quadrants, which shows the influence between each variable (Figure 8). Moreover, PCA analysis describes the distribution pattern of each station with the distribution of chl-a, nutrient and environmental parameters. Generally, the stations on Tengah Island have a different pattern for each station. The highest concentration values were found at Station 1 confirmed by high chl-a and ammonium values. This is a consequence of the location of Station 1 which is adjacent to the jetty and the closest to the land, so that the input of domestic waste is so dominant. However, the lowest concentration value was found at Station 4. This location is blocked by Sintok Island in the north side and by Karimunjaya Island in the west side. While station 2 & 3 have value in the middle range from the highest at station 1 and the lowest at station 4. This is due to geographical

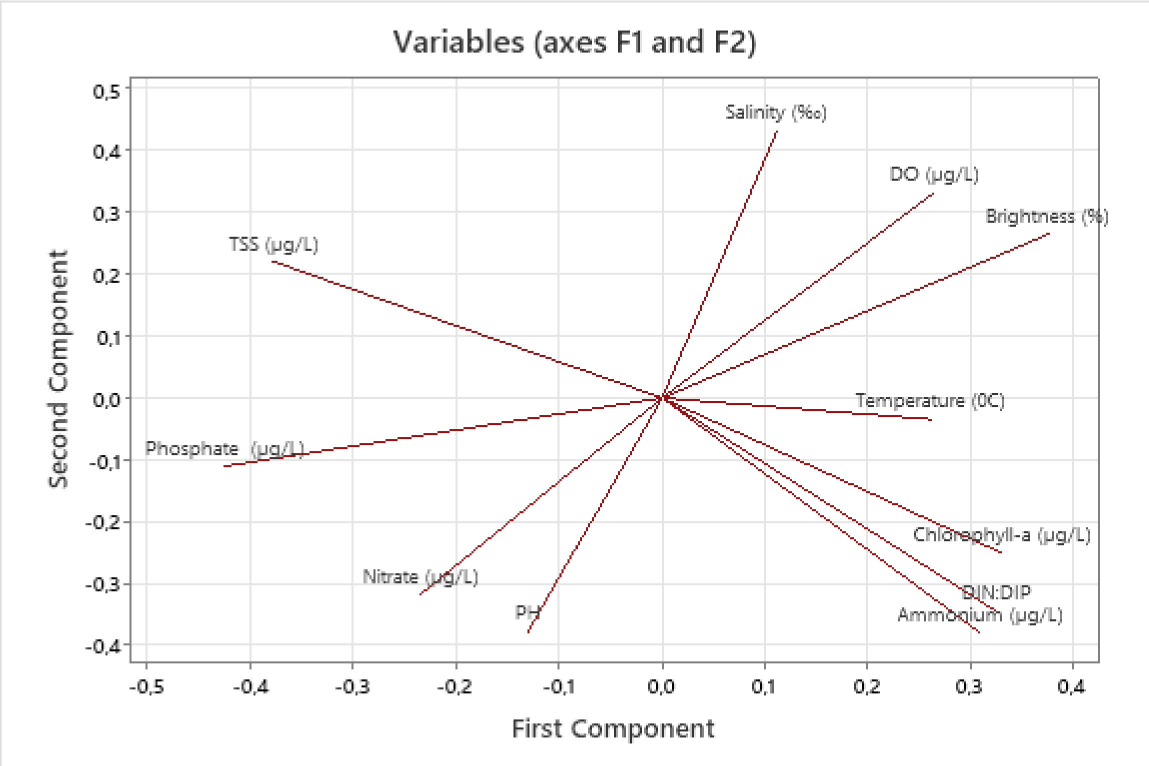

Figure 7. Correlation PCA of chl-a, nutrient and environment parameters in Tengah Island, TNKJ

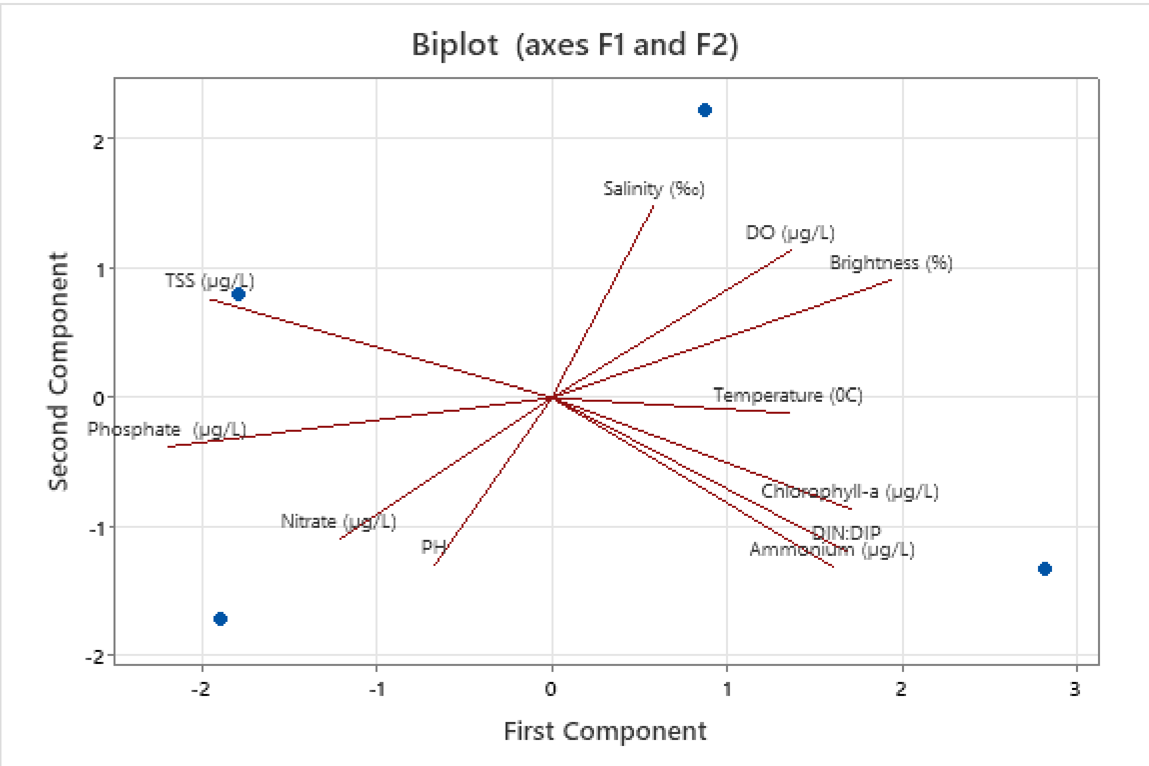

Figure 8. PCA Biplot of chl-a, nutrient and environment parameters in Tengah Island, TNKJ

factor since these two stations are adjacent to the high seas, on the east side so its distribution is influenced dominantly by currents, winds, tides, and waves (Abigail et al.. 2015).

CONCLUSIONS

Generally, the pattern of chl-a to nutrients and environmental parameters has a unique relationship for each location. This is because the concentration of chl-a is influenced by the dominant pollutant input and environmental parameters formed in these waters. In this study, the dominant pollutant input is a pollutant that contains high ammonia, than that with nitrate and phosphate composition. High ammonia content is more dominant derived from domestic waste and microbial activity. This is led by human activities through tourist resorts and jetty located on Tengah Island. Furthermore, the concentration of chl-a is also influenced by water quality parameters, especially TSS (with moderate correlation), brightness (moderate and positive) and sea surface temperature (low and positive). In general, Tengah Island waters are in great condition and still suitable for coral reef habitat as indicated by the value of chl-a, nutrients, and water quality within the permitted of seawater quality standards (Permen LH no. 51/2004).

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