Distribution of phytoplankton diversity and abundance in Maspari island waters, South Sumatera, Indonesia

IOP Conf. Series: Journal of Physics: Conf. Series **1282** (2019) 012105 doi:10.1088/1742-6596/1282/1/012105

Distribution of phytoplankton diversity and abundance in Maspari island waters, South Sumatera, Indonesia

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Abstract. Phytoplankton diversity is one of eutrophication indicator in Maspari island, south Sumatra, but its existence is strongly influenced by the physical-chemical parameters of the waters. This study aims to determine the distribution of phytoplankton diversity and their relationship with physical-chemical parameters in the waters of Maspari island. The methodology of research carried out was the physical-chemical parameter data collection, and phytoplankton samples were taken randomly on the surface of the water of 20 stations. Samples were identified types, analysed diversity, dominance and abundance calculations. For the relationship between diversity and abundance of phytoplankton with physical-chemical parameters of water carried out by principal component analysis (PCA). The results obtained that some of the physical-chemical parameters of Maspari Island waters have high variations such as turbidity ranging from 17,313 to 89,313 FTU. Current speed about 0.0-1,418 $m.s^{-1}$. Dissolved oxygen about 3.78±0.18-6.18±0.15 $mg.l^{-1}$. Nutrient concentrations such as NO_3 about 0-0.28 $mg.l^{-1}$ and PO_4 about 0-0.2 $mg.l^{-1}$, while the other parameters were smaller variations. Phytoplankton types found in four classes, namely Coscinodiscophyceae (7 species) with an abundance of 121,910.82 $cell.m^{-3}$ (49%), Dinophyceae (4 species) with an abundance of 54,649.68 $cell.m^{-3}$ (26%), Bacillariophyceae (3 species) with an abundance of 56,050.95 $cell.m^{-3}$ (23%), and Fragilariophyceae (1 species) with an abundance of 5,605.09 $cell.m^{-3}$ (2%). Diversity index shows low to moderate categories, while dominance in categories tends to dominate. PCA results showed that the physical-chemical parameters of the Maspari island waters of the identifier is the temperature, density, nitrate, salinity, DO and phosphate.

1. Introduction

Maspari island is between the Strait of South Bangka and South Sumatra. These waters have a fairly high dynamics, especially the occurrence of water mass mixing, where the process of mixing between fresh water from the mainland of South Sumatra and sea waters that occur continuously with strong currents. This phenomenon can cause high turbidity, varying salinity, as well as dissolved oxygen, pH and nutrient content. Water input from the mainland can carry nutrients that cause its content in high waters.

The dynamics that occur in these waters can cause an abundance and type of interesting phytoplankton to be studied. Phytoplankton abundance in the strait area is different compared to the open sea [1-5].

The dynamics of phytoplankton can be caused by water quality such as the concentration of nitrate and phosphate that are suitable for phytoplankton is 0.071 - 0.088 mg.l^{-1} and 0.004 - 0.005 mg.l^{-1} [3]. Current velocity is 0.07 m.s^{-1} [6]. The appropriate salinity, temperature and pH are 31.1 - 31.12 PSU, 30.7 - 30.9°C and 7 - 7.5 [7]. This study aims to determine the abundance and type of phytoplankton on the surface of the waters on Maspari island.

2. Materials and Methods

2.1. Study site and sampling stations

This research was conducted in October 2017 and August 2018 in the waters of Maspari Island, South Sumatra. The influence of fresh water in the location is known to be very high, where there are three large river estuaries that flow into these waters, namely the Banyuasin, Musi, and Lumpur Rivers. The random phytoplankton sampling station was 20 stations (Figure 1).

Figure 1. Map of study site

2.2. Samples and data collections

Phytoplankton sampling was carried out on the surface of the water about 10 liters at 20 stations with a 20 µm hole size plankton net. The plankton samples obtained were stored in a sample bottle and given 4% formalin preservative. Identification of the sample was carried out with a binocular microscope referred to [8]. The physical-chemical parameters of the waters taken at the surface <1 m include temperature, salinity, turbidity and density by using Conductivity Temperature Depth (CTD), current velocity by current meters, pH and dissolved oxygen by pH meters and DO meters. Whereas water nutrients such as nitrate (NO_3) and phosphate (PO_4) to analyzed referred to [9].

2.3. Data analysis

Phytoplankton diversity and abundance are calculated using diversity index, dominance and abundance based on the number of species found in each station. Diversity index follows Sannon

Winner Index [10] *in* [11], where H '= diversity; pi = ni / N; ni = number of cells per species divided by total individual species, with formulas:

$$H' = \sum pi \log pi \quad (1)$$

The Dominance Index is the number of individuals per species (ni) divided by the total number of individuals (N) squared. With formula:

$$C = \sum (\frac{ni}{N})^2 \quad (2)$$

Phytoplankton abundance is the number of cells per sample unit, where the abundance of phytoplankton (K), volume of filtered water sample (A), total area / container area of Sedgwick-Rafter Counting cell (B), observation area (C = 10 Liters), volume of filtered water (V), concentrate volume of Sedgwick Rafter Counting Cell (v), with a formula:

$$K = \frac{1}{A} x \frac{B}{C} x \frac{V}{v} x\, n \quad (3)$$

Data analysis was carried out using multivariate analysis, where the relationship between diversity and abundance of phytoplankton and physical-chemical parameters of the waters was analyzed using principal component analysis (PCA) with Xlstat 2018 software.

3. Result and Discussion

3.1. Physic-chemical parameters

The results of measurements of physical-chemical parameters on surface waters such as temperature, salinity, density, and pH showed little variation, while the velocity, dissolved and nutrient oxygen showed quite varied, including; Turbidity ranges from 17,313-89,313 FTU. Current speed ranges from 0.0-1.418 $m.s^{-1}$. Dissolved oxygen ranges from 3.78±0.18-6.18±0.15 $mg.l^{-1}$. Nutrient concentrations such as NO_3 ranged from 0-0.28 $mg.l^{-1}$ and PO_4 ranged from 0-0.2 $mg.l^{-1}$, while other parameters varied smaller (Figure 2).

Based on the turbidity distribution pattern on the surface it has a high turbidity value of 10-90 FTU, where turbidity is a standard that uses light effects as a basis for calculating raw water conditions in the FTU (Formazin Turbidity Unit) scale unit. Turbidity is caused by the presence of mixed objects or colloidal objects in the water and around the strait.

In general, surface currents have moved from the east to the northwest, where during the time the water moved from the Java Sea to the West of the Bangka Strait with a speed range of 0.4-0.5 $m.s^{-1}$. Besides that, in the northern part of the island there is a change in direction and speed of the current. There are three velocity locations indicating faster currents covering the Northeast and Southwest of Maspari island. This happens because of differences in bathymetry of waters that tend to be varied so that the current accelerates at a speed of 0.9-1.4 $m.s^{-1}$. Current generation factors on the surface are still dominantly influenced by wind and differences in water mass.

The distribution of surface water temperature has a slight variation, where the maximum is around 29.50 ^oC and the minimum temperature is around 28.25 ^oC. Changes in temperature have resulted in the circulation of water masses and have an effect on the condition of these waters. The salinity value on the surface of the waters in general is not much different, where a maximum of 31.5 PSU were located in the southeast and southwest of the island, with a minimum salinity value of 31 PSU located on the East of the Island. Salinity is an important factor for the spread of organisms in the sea, and oxygen is a limiting factor in determining the presence of organisms in the water. High salinity is generally found in deep waters (sea depth >100 m), whereas in shallow waters especially near land, salinity values are relatively lower.

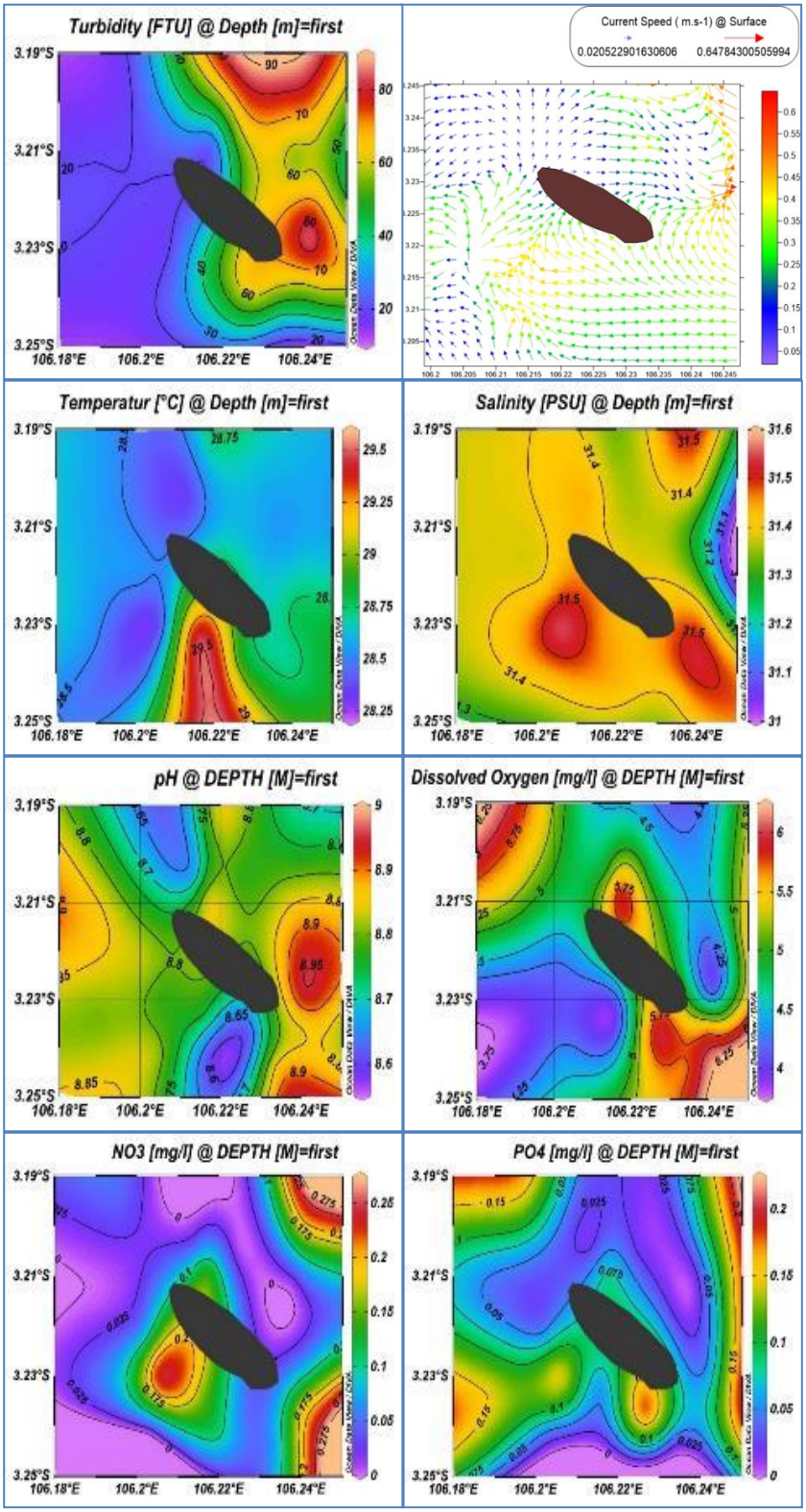

Figure 2. Physic-chemical parameters in Maspari island

The distribution of water on the surface pH of Maspari island waters have values ranging from 8.56 to 8.98. Different pH values on the surface waters is not very significant, and not overextending ideal pH value in sea water. The range of concentrations of oxygen dissolved in the water at the Maspari

island that is 3.7 to 6.2 mg.l^{-1}. The lower the dissolved oxygen levels with increasing depth, in which low levels of dissolved oxygen at a depth that is closer to the bottom of these waters are closely related to the amount of dissolved oxygen required for the decomposition of organic matter into inorganic substances by micro-organisms. While the activity of the photosynthetic process decreases.

In general, the nutrient content in Maspari island waters showed a low concentration. For nitrate (NO_3) ranged from 0.0-0.28 mg.l^{-1}, where there were only the three highest NO_3 concentration points, namely the southern, southeast and north eastern islands. Phosphate concentration (PO_4) ranges from 0.00-0.2 mg.l^{-1}, where the highest concentration is found in the southern and far islands towards the east.

3.2. Phytoplankton diversity

Type of phytoplankton in surface waters found to be slightly varied Maspari island, which is only found 4 class with 15 species that Coscinodiscophyceae are 7 species, Dinophyceae are four species, three species and Fragilariophyceae Bacillariophyceae 1 species. The distribution of the species Coscinodiscophyceae was found in almost all observation stations, while Dinophyceae, Bacillariophyceae and Fragilariophyceae were found at the 12th, 10th and 1st stations. There were three damaged samples, namely samples at stations 3, 9 and (Table 1).

Based on Table 1 the distribution of each species found to be uneven, where only *Dinophysis* sp was found at eight stations. The composition based on class found that Coscinodiscophyceae 49%, Dinophyceae 26%, Bacillariophyceae 23% and Fragilariophyceae 2% (Figure 3). The Coscinodiscophyceae class found in almost all stations, while three other classes were found in several stations, especially the Fragilariophyceae class was only found in three stations. The abundance in the phytoplankton class found to be different compared to the Mahakam delta waters [11], found the highest diversity and abundance in the Bacillariophyceae class.

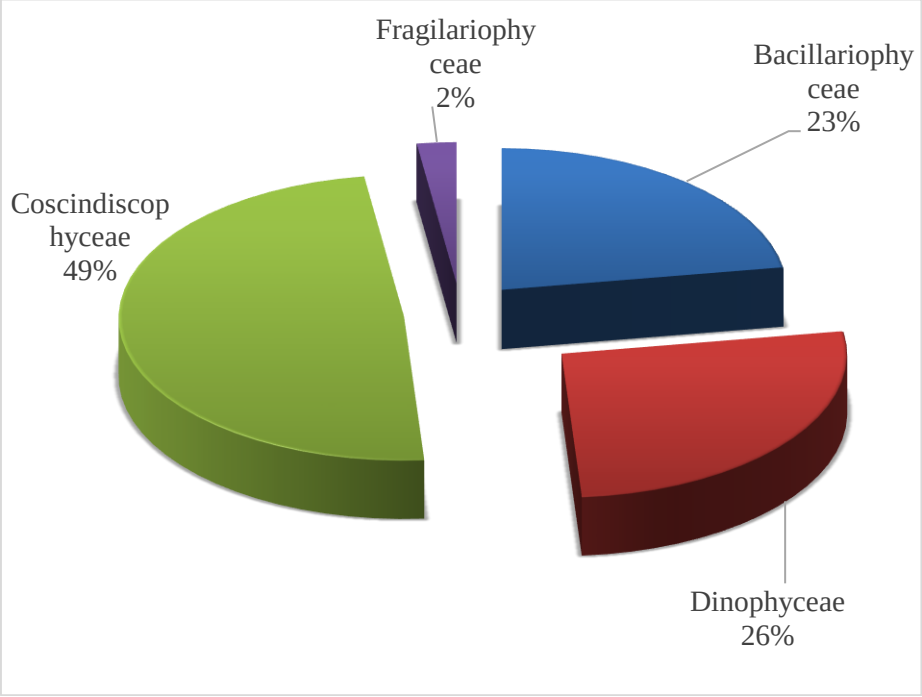

Figure 3. The class composition of phytoplankton

Table 1. Phytoplankton diversity in Maspari island

Class/ Species	Station																
	1	2	4	5	6	7	8	10	11	12	13	14	15	16	17	18	20
BACILLARIOPHYCEAE																	
Bacillaria sp.	-	-	-	-	-	-	-	-	-	+	+	-	-	-	+	+	-
Pleurosigma sp.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	+	+
Pseudo-nitzschia sp.	-	-	-	-	++	+	+	+	-	-	-	+	-	-	-	++++	-
DINOPHYCEAE																	
Ceratium sp.	-	-	++	+	-	-	-	-	+	+	-	-	-	-	-	-	-
Dinophysis sp.	-	-	+	-	+++	++	-	++++	-	+	-	+	-	-	-	+	+
Amphisolenia sp.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Torodinium sp.	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-
COSCINODISCOPHYCEAE																	
Actinocyclus sp.	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Skeletonema sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++++
Thalassiosira sp.	-	+	-	-	++++	-	-	-	++	-	-	-	-	-	-	-	-
Leptocylindrius sp.	+	+	-	-	-	-	-	-	+	-	+	-	-	+	-	-	-
Rhizosolenia sp.	-	-	-	-	+	-	-	-	+	-	-	-	-	-	+++	-	-
Chaetoceros sp.	-	-	-	-	-	+	++++	-	-	-	-	-	-	-	-	-	-
Coscinodiscus sp.	+	-	-	+++	+	-	+	+	-	-	-	+	+	+	-	++	+
FRAGILARIOPHYCEAE																	
Thalassionema sp.	-	-	-	-	-	-	-	-	-	-	-	++	-	-	-	-	-

Note: (-): 0 cell.m^{-3}; (+): 1-5000 cell.m^{-3}; (++): 5001-10000 cell.m^{-3}; (+++): 10001-15000 cell.m^{-3}; (++++): >15000 cell.m^{-3}

Diversity index (H') showed that overall the species of phytoplankton in the category of low to moderate. There are six stations that show the diversity of species in the medium category, while others were in the low category. For dominance index (C) were shown the variation of species ranges between 0.0-0.7, where the value of C found more than half of the observation station is above 0.5. This means that there were phytoplankton species that tend to dominated (Figure 4), whereas in the Mahakam delta waters, the diversity of phytoplankton found in the medium category and there was no dominated species [11].

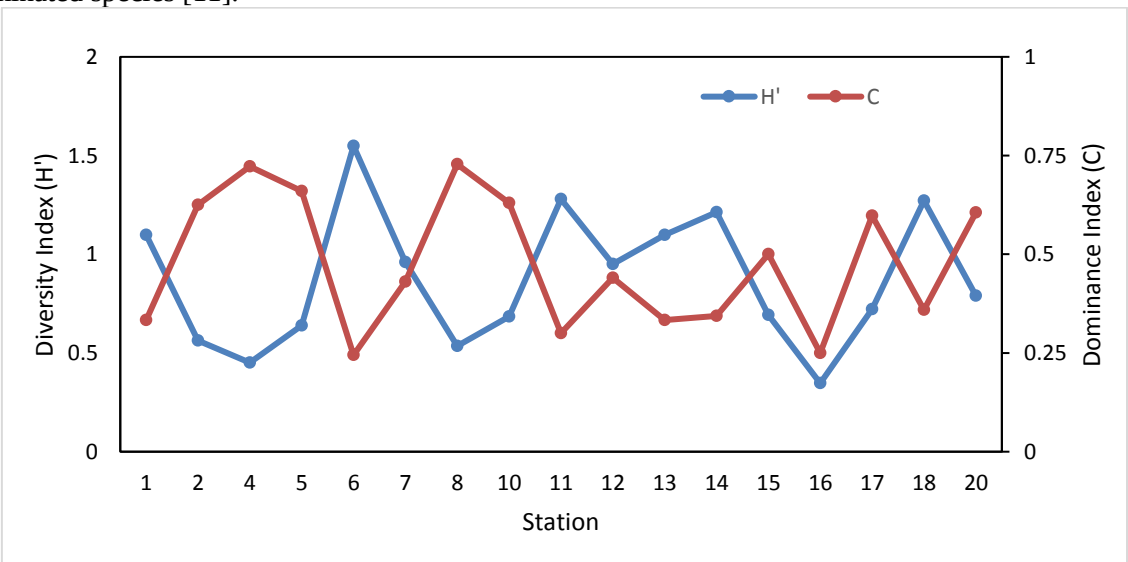

Figure 4. Diversity and dominance index in Maspari island

3.3. Phytoplankton abundance

The results of phytoplankton calculations obtained such as the value of abundance, diversity and dominance. Based on the abundance value indicates that there are eight species has an abundance of over 10,000 cell.m^{-3}, while the other showed fewer abundance.

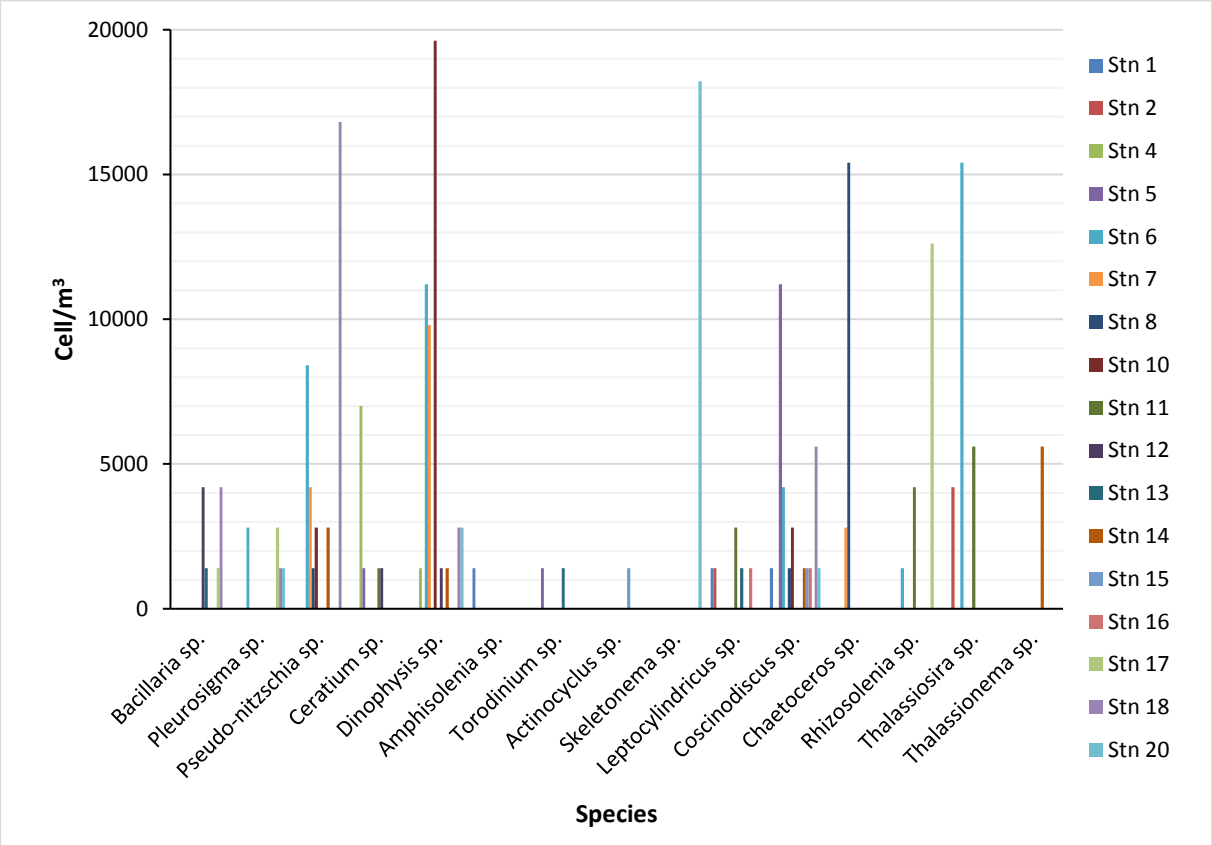

Figure 5. Abundance of phytoplankton in Maspari island

Based on Figure 5 the abundance of phytoplankton found to be highest in *Dinophycsis* sp 19,617.83 cell.m^{-3}, *Skeletonema* sp 18,216.56 cell.m^{-3}, *Ceratium* sp 16,815.28 cell.m^{-3}, *Chaetoceros* sp 15,414.01 cell.m^{-3} and *Thalassiosira* sp 15,414.01 cell.m^{-3}. The phytoplankton abundance showed uneven at each station, where the highest abundance found at station 6 to the number of cell 43,439.49 cell.m^{-3}, station 18 was 30,828.03 cell.m^{-3} and 5 stations are 25,222.93 cell.m^{-3}, whereas the other lower abundance. The highest abundance found in the southwest of the island, this is thought to be due to the influence of the supply of water from the main area. This abundance is much higher than the Mahakam delta waters [11].

Phytoplankton community structures such as abundance, diversity and dominance, are strongly influenced by nutrients as a food source [3, 12], the speed of currents carrying plankton [6, 13] as well as temperature, salinity and pH that support plankton growth [1, 7].

3.4. Correlation between physical-chemical parameters with phytoplankton diversity

Based on of principal component analysis (PCA), illustrated that there were five groups of data with each identifier. Three groups were in axes F1 and F2, and two groups were axes F1 and F3 of correlation between physical-chemical parameters with phytoplankton diversity (Figure 6)

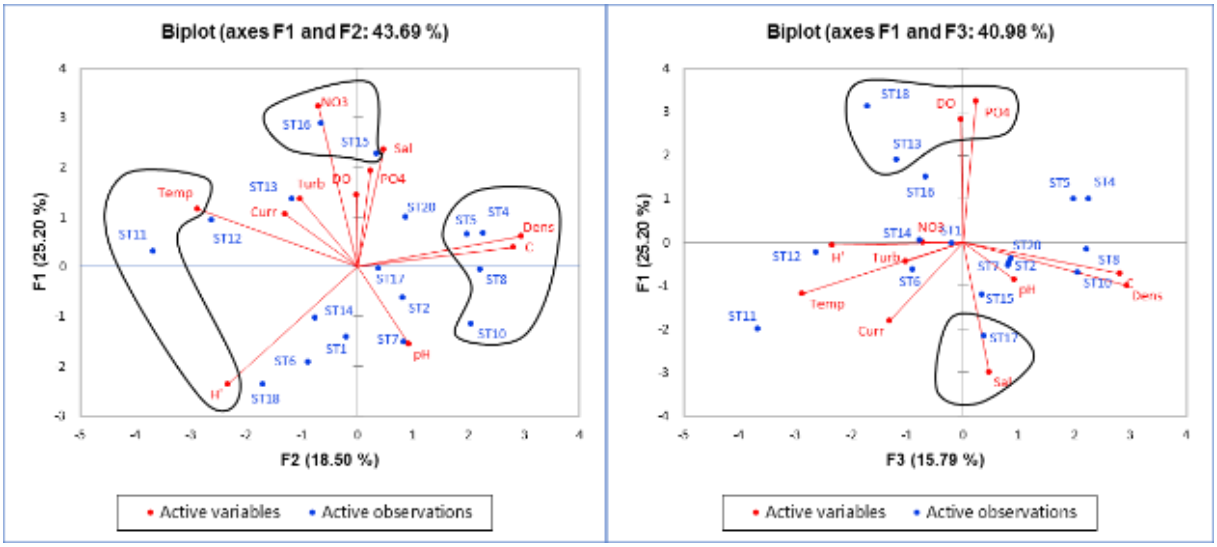

Figure 6. Principal Component Analysis

Description of the five groups of PCA is as follows; First group includes 4,5,8 and 10 station, the identifiers is the density and species domination. Density at this station reaches 1019.52-1019.54 kg.m^{-3}, with index of dominance species were 0.62-072 by *Dinophysis* sp., *Chaetoceros* sp., *Coscinodiscus* sp. and *Ceratium* sp. This group found in the northwest and southwest of Maspari island.

The second group involves station of 11 with the identifiers of surface temperature average at this station was 29.5^{o}C and species diversity (H' index) was 1.27. This station is located right in the southern part of the island with the dominance of the class by Coscindiscophyceae.

Third group includes 15 and 6 station, the identifier is the concentrations nitrate (NO_3) about 0.158 mg.l^{-1}. This group is located on the east and west side of the island, where higher nitrate concentrations are affected by the depth of shallow waters and are protected from currents. The group includes stations of 13 and 18 with the identifier is dissolved oxygen and phosphate. Dissolved oxygen concertation were 5.27 and 6.02 mg.l^{-1}, while phosphate concentration about 0.15 and 0.2 mg.l^{-1}. This increase in nutrients and oxygen is also influenced by the perfect mixing process in the region, where the process greatly affects the pattern of currents formed. Water currents too shown a major factor in the density of phytoplankton, where currents can carry phytoplankton to move from one place to another [13]. This group contributes to the F3 axis. This higher oxygen content occurs because there is stirring of the water mass which is characterized by increasing current velocity. For the fifth group describes at the station of 17 the identifier is salinity about 31.45 PSU. This station is in the eastern part of the island which is thought to have an influence on the supply of water from Java sea.

4. Conclusions

Maspari Island water has several different physical-chemical characteristics such as turbidity, dissolved oxygen, current speed, nutrient concentrations. Phytoplankton types were dominating by Coscinodiscophyceae (49%), Dinophyceae (26%), Bacillariophyceae (23%). Diversity index shows low to moderate categories, while dominance in categories tends to dominate. Phytoplankton abundance found high concentration, with uneven distribution. Based on PCA, the factors of identifier for type and phytoplankton distribution were temperature, density, temperature, salinity, dissolved oxygen and nutrients.

Acknowledgment

This research funded by Direktorat Riset dan Pengabdian Masyarakat, Direktorat Jenderal Penguatan Riset dan Pengembangan KEMENRISTEKDIKTI (PDUPT Grant no.: 093/SP2H/LT/DRPM/IV/2018).

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