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Seasonal Variation of the Composition and Density of Phytoplankton in Inner Ambon Bay

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Abstract

Seasonal variation of conditions in Ambon Bay affected the existence of phytoplankton organisms. These organisms are the dominant pelagic primary producers that convert inorganic substances into organic compounds through the photosynthetic processes. This study aims to determine the composition, density, and distribution of phytoplankton in relation to the characteristics of the waters. Phytoplankton sampling was conducted vertically in the euphotic zone by using a plankton net KITHARA every month from June 2011 to May 2012. This study found 4 classes of phytoplankton which consist of Bacillariophyceae (38 genera), Dinophyceae (13 genera), Cyanophyceae (1 genus), and Chrysophyceae (2 genera). Genus *Trichodesmium*, Cyanophyceae class dominated waters in East Season, Transition Season II, West Season and Transition Season I. ANOVA test of the abundance of phytoplankton obtained significant differences in the distribution of the both temporal and spatial, the correlation of the physical and chemical characteristics of the waters with an abundance of phytoplankton showed that East Season dominated by *Gonyaulax* (Dinophyceae) and *Bellerochea* (Diatom) which is influenced by phosphate, silica, ammonia, turbidity, pH and DIN:DIP. Transition Season I and West Season dominated by *Triceratium, Skeletonema, Bacillaria, Planktoniella, Ditylum, Diploneis*and*Prorocentrum* are affected by temperature, salinity, nitrite, ration of dissolved inorganic nitrogen to dissolved silicon, secchidepth and euphotic zone.

Keywords: Phytoplankton, Composition, Density, Season

1. Introduction

Ambon bay waters consist of Inner Ambon Bay and Outer Ambon Bay which are bounded by shallow waters. These waters confine the water circulation in Inner Ambon Bay (Anderson & Sapulete, 1981). Water mass condition in Ambon Bay waters in East Season with low air temperature affects the water level temperature of Ambon Bay. West Season with its high air temperature and speedy wind cause high water level temperature (Wenno, 1979).

Inner Ambon Bay and its surrounding have several functions and purposes, they become fishery and aquaculture areas, port harbor of Indonesian Navy and Water Police, traditional vessel and ferry harbor for inter-island defection, fishery harbor, water transportation path, hot water waste disposal from the State Electricity Company, vessel repairment quay, conservation, recreation, sport, and settlement areas. Inner Ambon Bay also gets nutrient input from lands through many rivers and Outer Ambon Bay. According to Tuhumury*et al.* (2007), in consequence of settlement construction on upper land, the sea gets its effect that in the heavy rainy season, sea water color turns to brownish. Population growth in the seashore, especially in estuary area highly plays the role to the occurrence of eutrophication which can be related to the dangerous algae blooming and waters quality deterioration problem (Domingues *et al.,* 2010), such as the disaster of dangerous algae *blooming* from the species of *Pyrodiniumbahamense* in Inner Ambon Bay in 1993 which takes human casualties (Wiadnyana, 1996), *Alexandrium affine* in 1997 (Wagey, 2001), *Pyrodinum* spp and *Alexandrium* spp (Tuhepaly, 2012).

Eutrophication is one of the main factor causing the aquatic environment deterioration in estuary (Qiu *et al.,* 2010). Therefore, nutrient's role, especially nitrogen and phosphor as the phytoplankton limiting factors becomes an important aspect to reduce and control eutrophication (Paerl, 2009). According to Pello and Huliselan (2007), 35 genera of phytoplankton which are found in Inner Ambon Bay includes genus of *Trichodesmium* (Cyanobacteria) with the density by 36.79% of the existing of total cell. According to Mulholland *et al*. (1999b *as referred in* LaRoche and Breitbart 2005), *Trichodesmium* can grow well at temperature of 28^{o}C, with tolerable temperature range between 20 to 34^{o}C.

This study aims to analyze the composition and distribution of phytoplankton relating to the waters characteristics in the Inner Ambon Bay Waters.

2. Research Methodology

This study is conducted for 12 months starting from June, 2011 to May, 2012 in Inner Ambon Bay, Ambon Island and Maluku Province waters. Geographic coordinates of these Maluku Islands are at 128^{0}19’4.03”- 128^{0}24’33”BTELand -03.66^{0}39’29”- 03.63^{0}30’30”S (Figure 1). Determination of 10 station position uses GPS-Garmin, Model 76CSx. Phytoplankton sampling method is conducted once a month as the represent of East Season, Transition Season I, East Season and Transition Season II, by having sampling as many of 12 times. Phytoplankton sampling is conducted vertically in euphotic zone using KITAHARA plankton net with fishing net diameters of 0.30 m, 1 m in its lenght, and 60 μm in its porosity size. Gained sample of plankton is preserved by using lugol of 1%.

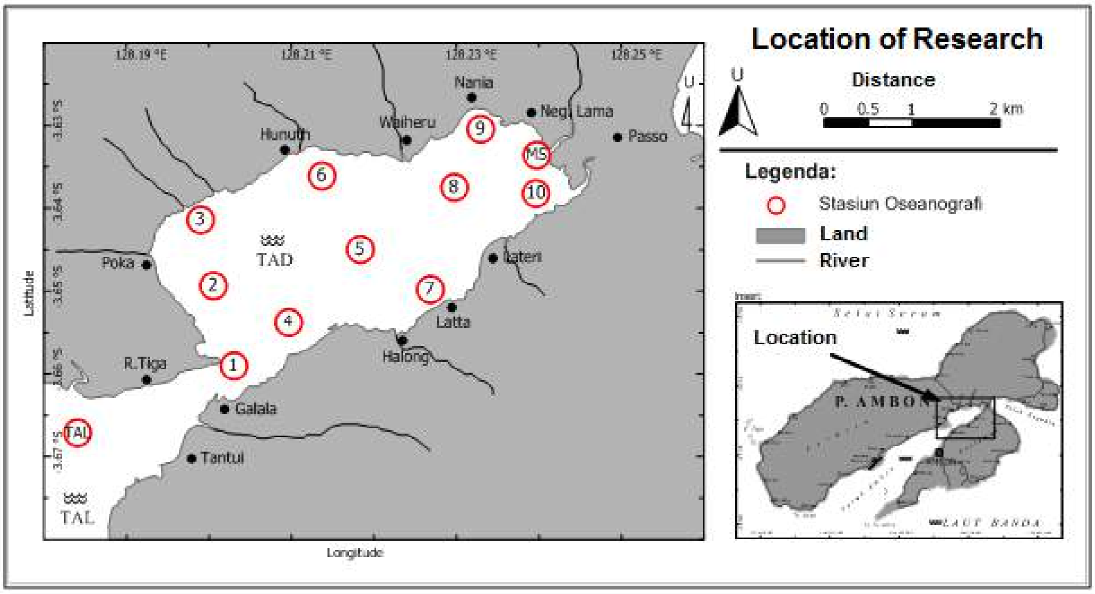

Figure 1. Research sites in Inner Ambon Bay waters

Euphotic zone is determined based on the percentage of sunshine intensity penetration when it falls to 1% of that at the surface. Surface sunshine intensity is measured using Automatic Weather Station (AWS) type JY 106 from Meteorology and Geophysics Agency of Ambon. Magnitude of the light intensity in each depth is calculated based on Beer-Lambert (Walsby, 2001) equation as follows:

$$I_z = I_o e^{-kz} \quad (1)$$

I_z : light intensity at the depth of z

I_0 : light intensity at the depth of z0

k : attenuation coefficient

Attenuation coefficient can be calculated based on mathematical equation proposed by Tillman et al. 2000 as follows:

$$k = 0{,}191 + 1{,}242/S_d \quad (2)$$

Sd (in meters) is a light penetration depth measured using sechi disc with diameter of 30 cm.

Water quality parameters such as temperature, salinity, density, turbidity, and phytoplankton biomass (Chl-a) are calculated by using CTD-ALEC, Model ASTD-687. Water sampling uses Nansen bottle. pH is measured by using pH meter, dissolved oxygen by applying Winkler titration method, while nitrate, nitrite, ammonia, phosphate, and silica uses standard method (Parson et al., 1984). Phytoplankton identification is conducted according to Yamaji (1984) and Newell and Newell (1977) only on its genus level. Phytoplankton cell abundance is calculated by the equation of Utermohl 1958, as referred in Damar 2003) as follows:

$$N = \frac{n(Ls/Lp)x(V.1/V.S)}{Vol.2} \quad (3)$$

N : Phytoplankton abundance (mL^{-1} cell)

n : Countable number of cell (cell)

Ls : Sedgwick-rafter area (mm^2)

V.1 : Observed *Sedgwick-rafter* area (mm^2)

V.2 : Water volume based on precipitation result sample (mL)

V.S : *Sedgwick-rafter counting cell* volume (mL)

Temporally and spatially phytoplankton distribution data is analyzed by one-way ANOVA. If there is an obvious difference, phytoplankton distribution data analysis is followed by Duncan's Post-hoc equation test. To determine the characteristics variation of environment variable with phytoplankton community, researcher uses Canonical Correspondence Analysis (CCA) ordination calculation by using MVSP version 3.1.

3. Result and Discussion

3.1 Composition and Density of Phytoplankton

Composition and distribution analysis result of phytoplankton found that there are 4 phytoplankton classes, they are Bacillariophyceae (Diatom), Dinophyceae, Cyanophyceae and Chrysophyceae. They are consist of 38 genera of Bacillariophyceae, 12 genera of Dinophyceae, 1 genus of Cyanophyceae and 2 genera of Chrysophyceae. Table 1 shows that phytoplankton cell abundance dominating waters in East Season, Transition Season II, West Season, and Transition Season I is the class of Cyanophyceae from the genus of *Trichodesmium* in the highest percentage. Similar with Pello and Huliselan (2007), they found that *Trichodesmium* is dominant in Inner Ambon Bay waters in East Season. Dwiono and Rahayu (1984) found that genus of *Chaetoceros* dominates the waters in those four seasons.

Table 1. Dominant phytoplankton species in four seasons (cell/m^3)

East season	%	Transitional season I	%	West season	%	Transitional season II	%
Trichodesmium sp	67.86	*Trichodesmium sp*	29.57	*Trichodesmium sp*	33.11	*Trichodesmium sp*	35.02
Nitzschia sp	10.70	*Chaetoceros sp*	22.63	*Chaetoceros sp*	31.21	*Chaetoceros sp*	30.40
Dinophysis sp	5.82	*Bacteriastrum sp*	14.79	*Alexandrium sp*	12.76	*Bacteriastrum sp*	8.79
Chaetoceros sp	2.83	*Ceratium sp*	10.18	*Bacteriastrum sp*	11.02	*Thalassiothrix sp*	7.48
Stepphanopyxis sp	2.56	*Alexandrium sp*	9.35	*Ceratium sp*	3.36	*Thalassionema sp*	5.19
Alexandrium sp	2.26	*Rhizosolenia sp*	3.23	*Climacodium sp*	2.51	*Nitzschia sp*	4.49
Ceratium sp	2.23	*Dinophysis sp*	2.75	*Dinophysis sp*	1.76	*Rhizosolenia sp*	2.28
Bacteriastrum sp	1.58	*Thalassionema sp*	2.27	*Rhizosolenia sp*	1.68	*Alexandrium sp*	2.16
Rhizosolenia sp	0.94	*Nitzschia sp*	2.10	*Hemiaulus sp*	0.84	*Ceratium sp*	1.32
Climacodium sp	0.56	*Hemiaulus sp*	0.88	*Nitzschia sp*	0.39	*Dinophysis sp*	0.52

Temporally (inter-season), the average of phytoplankton abundance in waters is high in Transition Season II (Figure 2) (ANOVA, $P<0.01$), Transition Season II gives a high influence on the phytoplankton abundance in an obvious level by 5%. Spatially phytoplankton abundance distribution (inter-station) is significantly different (ANOVA, $P<0.01$) in every station. It is seen that every station shows similar variation level against phytoplankton abundance at an obvious level by $\alpha = 5\%$.

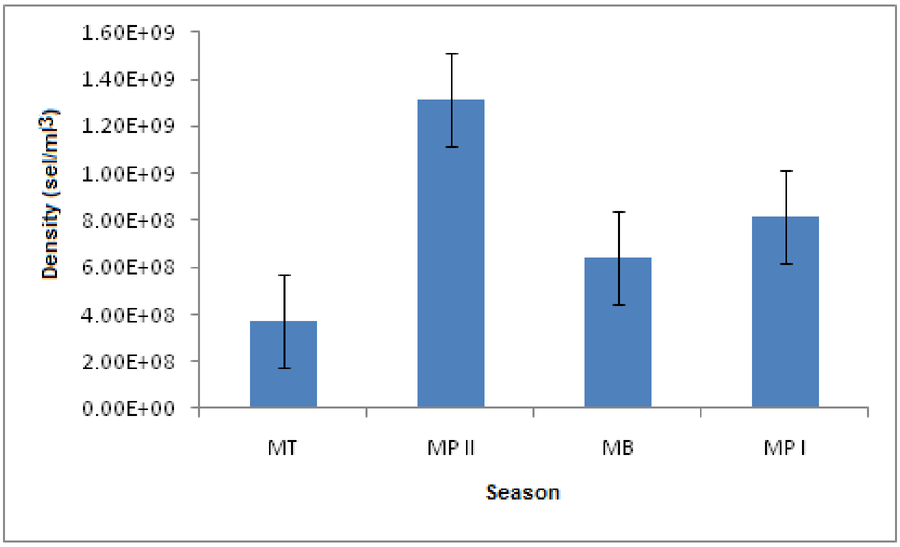

Figure 2. Phytoplankton abundance in East Season (ES), Transition Season II (TS II), West Season (WS) and Transition Season I (TS I)

During East Season, density of *Trichodesmium* (Cyanophyceae) is 2.5×10^8 cell/m^3 (67.86% of the existing of total cell), Bacillariophyceae is 21.49% and Dinophyceae is 10.65%. Furthermore, a succession occurs when Transition Season II, West Season and Transition Season I marked by the increasing amount of Bacillariophyceae that is 47.11%, 48.19% and 60.48% respectively by the presence of Chaetoceros genus by 22.63%, 31.21% and 30.40% respectively. According to Rodier and Borgne (2010), diatom emerges with a higher density after the *blooming of Trichodesmium* in rainy season. The blooming of Trichodesmiumsp begins at temperature of 24.2 to 28.6 ^{o}C (Rodier & Borgne, 2008). *Blooming of Trichodesmium* occurs in East Season because of the low degree of waters temperature (26.08 to 27.57 ^{o}C) and its density begins to decrease by the average waters temperature raising in Transition Season II, West Season and Transition Season I respectively (28.32 to 29.94 ^{o}C, 30.25 to 30.86 ^{o}C and 29.78 to 30.36 ^{o}C).

Composition and density of phytoplankton in East Season, Transition Season II, West Season and Transition Season I are presented in Figure 3, while composition and density of phytoplankton in every month during the conducting study is presented in Figure 4.

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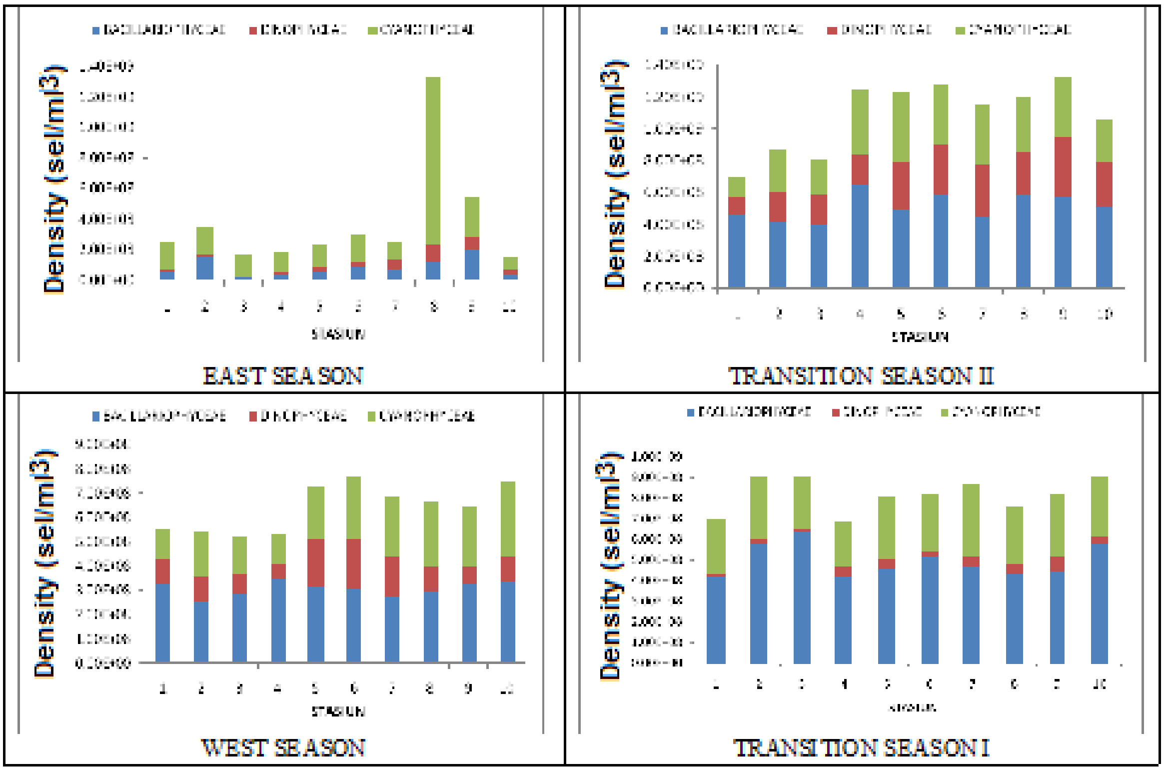

Figure 3. Composition and density of phytoplankton in East Season, Transitional Season II, West Season and Transitional Season I

Figure 3 shows that the highest density in East Season is in the station 8 (in the middle between Lateri and Waiheru) that is 1.3 × 10^9 cell/m^3 (1.3 × 10^6 cell/L) with *Trichodesmium*density 1.1 × 10^6 cell/L (83%) in the depth of 0 to 10 meter. While in Banda Sea waters, density of *Trichodesmiumthiebautii* in Transition Season II (November) is between 0 and 8.8 × 10^2 cell/m^3 on the water surface (Sediadi, 2004). The high density of *Trichodesmium* in station 8 is due to the deeper light penetration and euphotic zone in this station, respectively 6 m and 10 m. According to Nontji (2007), *Trichodesmium* is often found in the waters of Indonesia, sometimes appears with a huge population explosion and soon disappears quickly. In Transition Season II, West Season and Transition Season I, Bacillariophyceae is generally found with the highest density in every station, then followed by Cyanophyceae and Dinophyceae.

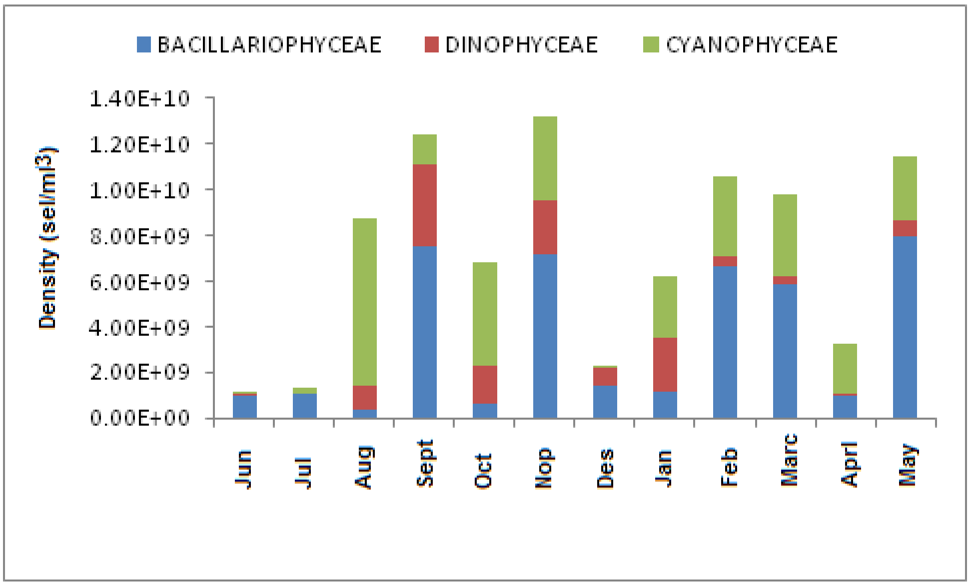

Figure 4. Composition and Density of phytoplankton in Inner Ambon Bay

Figure 4 shows that the highest abundance of Cyanophyceae (*Trichodesmium*) is in August, October and March, respectively (7.3×10^9 cell/m^3), (4.6×10^9 cell/m^3) and (3.6×10^9 cell/m^3). While high Bacillariophyceae density is obtained in September with *Chaetoceros* content 35.34% (4.3×10^9 cell/m3) and *Bacteriastrum* 9.76%. *Bacteriastrum* content in November is 26.93% and *Chaetoceros* (2.8×10^9 cell/m^3) 21.13%, *Chaetoceros* content in February (4.3×10^9 cell/m^3) 40.99% and *Bacteriastrum* 17.54%, March content of *Chaetoceros* (4.2×10^9 cell/m^3) 42.75% and *Bacteriastrum* 17.54% and May content of *Chaetoceros* (2.5×10^9 cell/m^3) 22.40% and *Thalassiothrix* 15.59%. Furthermore, number of Dinoflagellata increases in September with *Alexandrium* content (3.0×10^9 cell/m^3) 24.48%, content of *Ceratium* in November (1.8×10^9 cell/m^3) 13.57% and January with *Alexandrium*content (2.2×10^9 cell/m^3) 35.41%. Generally, Dinoflagellata is in the lowest concentration compared to others. According to Madhu *et al.* (2007), dinoflagellata community is less abundance in estuary area throughout the year compared to diatom.

3.2 Characteristics of Environmental Variables of Phytoplankton Community

Ordination result between phytoplankton community with environmental variables of corresponding season and CCA is presented in triplot graphics (Gambar 5).

From three main axis, it is obtained eigenvalue 0.111, 0.094 and 0.053 with explained cumulative presentation information 61.54%. Triplot graphics generally shows three groups of observation station. Group I represents East Season which is dominated by *Gonyaulax* (Dinophyceae) and *Bellerochea* (Diatom) affected by pH, phosphate, silica, ammonia, turbidity and DIN:DIP. *Gonyaulax* and *Bacillaria* abundance is very much determined by phosphate. Zhou *et al.* (2008) stated that the growth of diatom is limited by the low phosphate concentration in the sea, limited phosphate and nitrogen increase will cause dinoflagellata *blooming*. Group II represents Transition Season I and West Season which are dominated by

Triceratium, Skeletonema, Bacillaria, Planktoniella, Ditylum, Diploneis and*Prorocentrum*affected by temperature, salinity, nitrite and DIN:DSi, depth of light penetration (secchi depth) and euphotic zone. According to Huang *et al.* (2004), Diatom (*Skeletonemacostatum*) is a phytoplankton species with euryhaline and eurythermal nature, fast grown in a eutrophic condition. Group III represents Transition Season II dominated by *Noctiluca, Streptotheca* and *Eucampia*. The longer arrow (variable) pointed to genus and observation station, the bigger contribution of the variable to the genus and observation station, if the longer arrow form an angle (≈180^{o}), then the influence of the variable tend to be negatively correlated with the opposite variable.

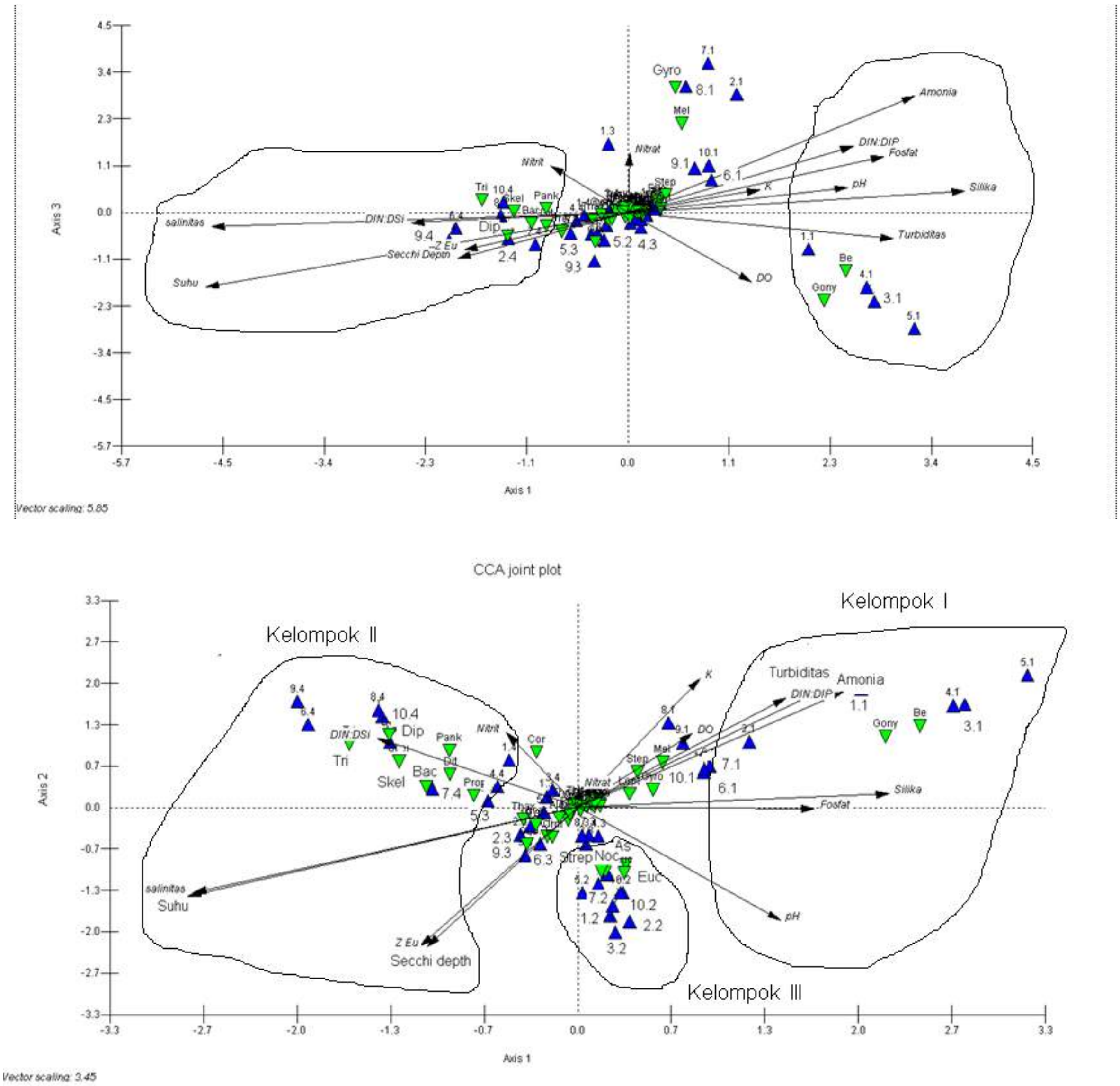

Figure 5. Triplot graphics of ordination result between phytoplankton density with environmental variables in Inner Ambon Bay

4. Conclusion

It is concluded from the result of this study that 53 genera of phytoplankton found is dominated by diatom. *Trichodesmium* of Cyanophyceae class with highest percentage in East Season. Correlation between physical characteristics of chemical of waters with phytoplankton abundance shows that East Season of *Gonyaulax* (Dinophyceae) and *Bellerochea* (Diatom) is affected by phosphate, silica, ammonia, turbidity, pH and DIN:DIP. Transition Season I and West Season, *Triceratium, Skeletonema, Bacillaria, Planktoniella, Ditylum, Diploneis*and*Prorocentrum* are affected by temperature, salinity, nitrite, DIN:DSi, *secchi depth* and *euphoticzone* .

5. Suggestion

Future research is best suggested to focus on factors effecting *blooming Trichodesmium* and environmental management around Inner Ambon Bay waters.

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