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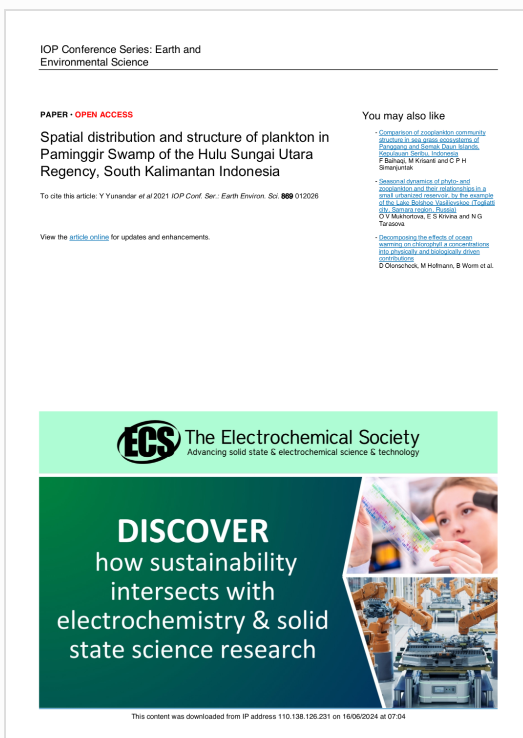
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Spatial distribution and structure of plankton in Paminggir Swamp of the Hulu Sungai Utara Regency, South Kalimantan Indonesia

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Spatial distribution and structure of plankton in Paminggir Swamp of the Hulu Sungai Utara Regency, South Kalimantan Indonesia

Y Yunandar[1,2*], H Effendi[3], W Widiatmaka[4], Y Setiawan[3,5]

[1] Study Program of Natural Resources and Environment Management, Graduate School, IPB University, Baranangsiang Campus Bogor 16144, Indonesia

[2] Department of Aquatic Resource Management, Faculty of Fishery and Marine, Lambung Mangkurat University, Banjarmasin 70123, Indonesia

[3] Environmental Research Centre, IPB University, Bogor, Indonesia

[4] Department of Soil Sciences and Land Resources, Faculty of Agriculture, IPB University, Dramaga Campus, Bogor 16680, Indonesia

[5] Department of Forest Resources Conservation and Ecotourism, Faculty of Forestry, IPB University, Dramaga Campus, Bogor 16680, Indonesia

*Corresponding author: nandarco@yahoo.com

Abstract. Plankton is a biota community that is able to adapt and serve as natural food for fish. This study aims to analyze the structure of the plankton community and its spatial distribution so that this research can be used as information for swamp aquaculture. This research was conducted in July and August 2019. Sampling was done at ten stations by considering the duration of inundation. The method used was quantitative exploration and inverse distance weighting (IDW). The results showed that the swamp waters of Paminggir and Danau Panggang had the highest abundance of phytoplankton (850 cells/liter), the lowest in Ambahai (150 cells/liter) in July and Bararawa (180 cells/liter) in August 2019. Zooplankton (10 cells/liter) has been identified in Jenamas with the lowest abundance, and the highest (70 cells/liter) in Babirik in August 2019. Bacillariophyceae was dominate with relative abundance of 53% species and the most zooplankton comes from Protozoa by 50%. The range of index values of diversity, evenness and dominance of phytoplankton were 1.79 to 0.21 while zooplankton were 0.46 to 0.72. Phytoplankton with appropriate abundances are spatially distributed in the western part of the swamp along the Ambahai and Babirik while the spatial distribution of the abundance of zooplankton properties clustered in the middle and southern of the swamp. Water quality parameters of the nitrate ranged 0.13 – 0.25 mg/l and phosphate ranged 0.12 – 0.52 mg/l.

1. Introduction

A swamp is an area permanently saturated with water, inundated most of the year with a depth of less than 5 meters, the water tends not to move or not to flow. The water supply from the Paminggir swamp Hulu Sungai Utara has come from rainwater, runoff from the Negara River and the Barito River which establish an inundation. Swamps is one of the ecosystems that supply inland fisheries in South Kalimantan. The composition of organic matter, nitrate, phosphate, and phytoplankton are a factor that plays an important role in supplying the availability of natural food in the waters. Water productivity is highly dependent on phytoplankton biomass because of its ability in photosynthesis which produces oxygen and food for fish. Phytoplankton growth is highly dependent on the availability of organic matter, nutrients in the form of nitrate and phosphate. The dominant nutrients found in the waters are used by phytoplankton and other biota in the food chain process [1]. Plankton is used by fish as natural food, the composition of freshwater plankton is lower in diversity than marine ecosystems [2-5]. The limitations of natural feed supplied by the plankton result in the low biodiversity of fish in freshwater [6], in addition to illegal fishing activities.

Changes in the structure of plankton affect the growth, development, survival, and reproduction of many aquatic organisms. Plankton can act as an indicator of aquatic fertility [7,8] especially for the development of swamp fisheries. Therefore, the purposes of the research were to analyse the plankton community structure and spatial distribution, hence this research can be used as an information for the suitability of swamp aquaculture.

2. Research Methods

2.1. Study site

This research was carried out from July to August 2019. The location of the research was based on the swamp ecosystem formed from the runoff of the major rivers in South Kalimantan, namely Barito and Negara. This location is in the Hulu Sungai Utara Regency, especially in Paminggir, Danau Panggang, Tabukan and Babirik Rivers (Figure 1). The delineation of the study area is at coordinates $2^0$1'37' to $2^0$35'58' South Latitude and between $114^0$50'58' to $115^0$50'24' East Longitude with an area of 43,275.38 ha. Most of the surrounding population utilizes swamp waters for economic purposes, consumption and water transportation.

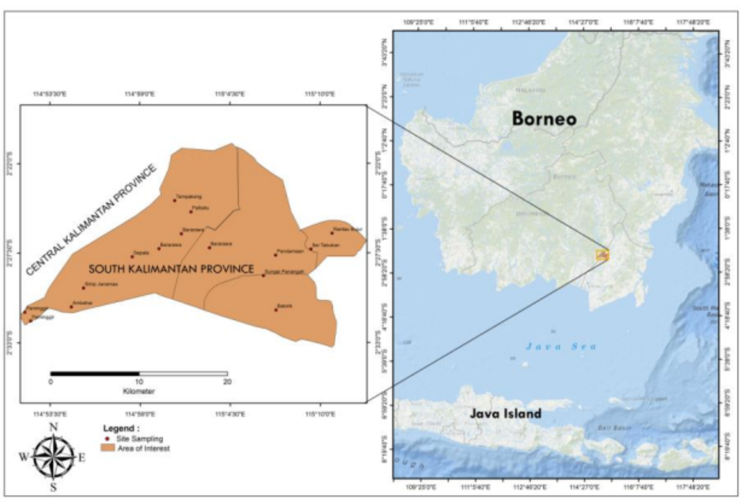

Figure 1. Location of sampling site in swamp Paminggir.

2.2. Materials and Methods

Plankton net field sampling equipment with 25 mesh size for phytoplankton and 40 mesh size for zooplankton, cool box, 100 millitre bucket, 50 ml sample bottle, 5x5m line quadrant transect, label paper, camera, GPS, and spectrophotometer. The tools used in the research in the laboratory are Sedgwick-Rafter, inverted microscope (phase contrast) with 4 x 10 accuracy, binocular microscope, cover glass, dropper, pipette stamp, identification book [9-12]. The content of dissolved nitrate and phosphate was analysed using spectrophotometric methods at a wavelength of 885 nm for phosphate and 543 nm for nitrate.

2.3. Research Procedure

Plankton samples were taken from the research site by filtering 10000 ml of water using plankton net size no 25. The repetition was carried out at twice each station. The filtered water sample was put in a 100 ml sample bottle and then given two drops of 4% formalin solution. Preservation of plankton is carried out with a 2-5% formalin solution. Sampling of zooplankton was carried out used planktonet size no 40, and preserved using lugol as much as 3-5 drops. Nitrate and phosphate samples were taken directly together with plankton sampling and analyzed in the laboratory with a spectrophotometer. Samples were taken according to the results of typological analysis at 10 site sampling marked with GPS, there were Ambahai, Tampakang, Palbatu, Bararawa, Sapala, Jenamas, Paminggir, Pandamaan, Sei Panangah, and Babirik. Sampling was carried out during the dry season at the beginning of July and August 2019. The data measured is the structure of the zooplankton and phytoplankton was determined by calculating the Shannon-Wiener diversity index, species abundance index, evenness index, and Simpson dominance index. Furthermore, the density of plankton, nitrate and phosphate was analysed spatially. The results of the analysis of plankton and water quality were then spatially interpolated using GIS techniques and procedures. Calculation of the abundance of phytoplankton per litre using the APHA formulation [13]:

$$N = \frac{T}{L} x \frac{P}{p} x \frac{V}{v} x \frac{l}{w} \quad (1)$$

Information:
N : Number of plankton per litter
T : Cover glass area (mm^2)
L : Field area (mm^2)
P : Number of recorded plankton
p : Number of observed fields (10)
V : Volume of filtered plankton sample (100 ml)
v : Volume of plankton under cover glass (mm^2)
w : Volume of filtered plankton sample (10^4 ml)

Shannon-Wiener diversity index:

$$H' = \sum_{n=1}^{s} Pi \ln \; ni/N \quad (2)$$

Information :
H' : Diversity Index
S : Number of taxa
P_i : Proportion of number of individuals
ni : Number of individuals of each species (cells)
N : Total individuals of all species (cells)

Evenness Index :

$$E = \frac{H'}{H'max} \quad (3)$$

information:
E = Evenness index
H' = Diversity index
H' max= ln S

Dominance Index

$$D = \sum_{i=1}^{s} Pi^2 \quad (4)$$

Information:
D = Dominance index
S = Number of taxa
P_i = Proportion of number of individuals

The dominant index is between 0 - 1. A dominant index value of <0.5 means that no type is dominated when the dominant index>0.5 means there is a specific type of dominance.

2.4. Spatial Analysis

GIS modelling tool is used to perform inverse distance weighting (IDW), which estimates point values without samples or data gaps in the study area. This approach is especially useful when studying the vast swamp water environment, where limitations such as time and money hinder data collection throughout the study area. Spatial interpolation is the prediction of a variable at an immeasurable location based on a sample at a known location. The concept of calculation is relevant for phytoplankton and zooplankton, where closer points are considered similar as a result of food webs. All data is calculated using ArcGIS, using the following equation [14-16]:

$$Z_j = \Sigma_i \frac{zi/\binom{n}{dij}}{1/\binom{n}{dij}} \quad (5)$$

Information:
Z : Estimated value for unsampled point (j)
Z_i : Known sample value (i),
d_{ij} : Distance between known sample (i) and unsampled point (j)
n : User exponent specified for weighting

3. Results and Discussions

Type phytoplankton *Diatoma* sp. of the class was the organism that most often appears at the research site during observation. Phytoplankton found throughout the research station consisted of 81 genera in July from four classes, while in August it increased to 83 genera. Changes in phytoplankton structure were present in Bacillariophyceae and Chlorophyceae. Changes in phytoplankton structure were present Bacillariophyceae and Chlorophyceae. The results of the analysis in July 2019 showed that Bacillariophyceae with 8 genera, Chlorophyceae with 5 genera and Cyanophyceae 3 genera. While in August there was an increase in the class of Chlorophyceae into 6 genera, and Bacillariophyceae into 9 genera. The following classes and phytoplankton genera were shown in Table 1.

Table 1. Phytoplankton genera found at the site of the study

Class	Genus	Sampling site/location
Cyanophyceae	*Oscillatoria, Coelastrum, Gloecystis*	Palbatu, Bararawa, Sapala, Babirik, Jenamas, Pandamaan
Chlorophyceae	*Gonatozygon, Chara, Homidium, Roya, Closterium, Spirogyra*	Palbatu, Bararawa, Sapala, Babirik, Jenamas, Pandamaan, Ambahai, Tampakang, Paminggir, Panangah
Bacillariophyceae	*Cymatopleura, Coconeis, Diatoma, Nitzschia, Navicula, Synedra, Melosira, Corethron, Surirella*	Palbatu, Bararawa, Sapala, Babirik, Jenamas, Pandamaan, Ambahai, Tampakang, Paminggir, Panangah

Cyanophyceae was only present in 6 locations, while Chlorophyceae was spread across all site sampling but the population was not as large as Bacillariophyceae from July until August. The phytoplankton composition of Bacillariophyceae was more dominant than Chlorophyceae and Cyanophyceae from the sampling site (Figure 2). This phylum rapidly replicated when organic matter increased, resulting in unstable aquatic environmental quality plus isolated inundation areas [17,18]. Chlorophyceae can grow rapidly in swamp aquatics in certain seasons known as the phenomenon of eutrophication. Bacillariophyceae, better known as diatom [19] were a natural feed for Climbing pearch (*Anabantidae*) which is a black fish and catfish that is a white fish [20]. Black fish are swamp aquatic resident fish and white fish are river fish, which can migrated when flooding occurs. There is also a *Navicula sp.* preferred omnivorous fish [21].

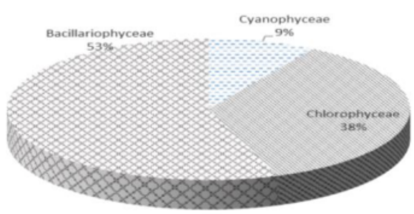

Figure 2. Structure community of phytoplankton.

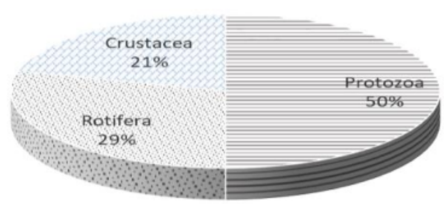

Figure 3. Structure community of zooplankton.

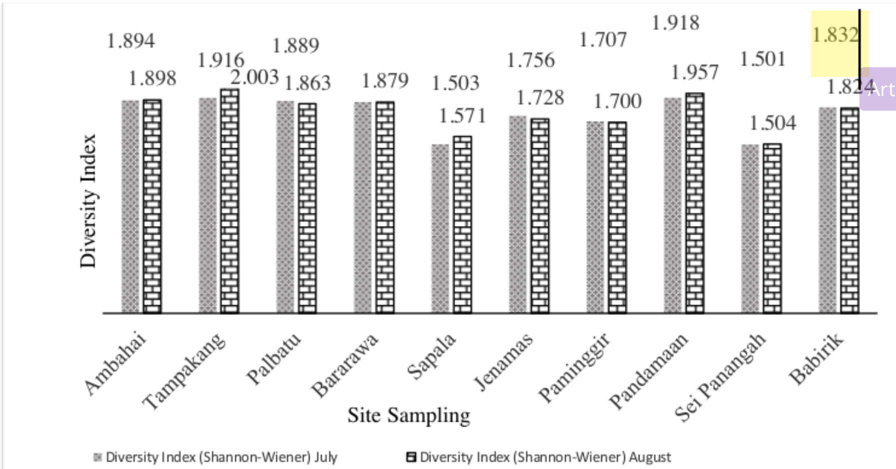

Figure 4. Diversity index of phytoplankton.

The type and diversity of phytoplankton in August was relatively higher than in July, especially in areas with relatively high density of aquatic plants (Figure 4). The value of phytoplankton diversity index in the waters in Paminggir Swamp has a moderate diversity because the value of diversity ranged from 1.504 to 1.917. The greater the value of H' indicates the more diverse life in these waters. Conditions in this location, relatively sensitive to changes in small environmental components. Phytoplankton evenness values ranged from 0.105 - 0.948 (Figure 5). The number of individuals of each type was not much different. A evenness index value close to 1 indicates that evenness between species can be said to be evenly distributed or the number of individuals in each species is almost the same. The dominant value of phytoplankton was classified as moderate ranged from 0.182 - 0.251 (Figure 5). Evenness index was inversely proportional to the diversity index, due to the fluctuated mass of water from rivers so that plankton easily drift. This opinion is supported by [22,23] stated that the high diversity index shows that at this location it is feasible in terms of the availability of natural feed for inland fisheries activities. The intensity of sunlight used as a material to produced nutrients for phytoplankton. Phytoplankton contain chlorophyll that can photosynthesis absorbing solar energy to convert inorganic materials into organic matter. The lowest amount of diversity was found at Sei Panangah station, the location was an area where there isn't *Eichornia crassipers*. There is less abundance than other stations due to the influence of water quality [24-27].

Zooplankton found in Paminggir Swamp during July and August consisted of Rotifera, Protozoa and Crustacea (Figure 3). Number of species crustacea was the lowest. Extreme peat swamp water conditions cause crustacea to be incapable of tolerant or adapting to environmental changes. Crustacea is the most recognizable type of plankton compared to other types of plankton, both in terms of larval and adult form, sometimes also found in the meroplankton group of high-level Crustacea in the form of larvae.

The existence of zooplankton contributes to the existence of potential fish resources [28]. The role of zooplankton in the mechanism of the food chain as a consumer of the first level which feed on phytoplankton and eaten by nektons [4,29]. Zooplankton are more diverse in Tampakang, Ambahai and Palbatu areas. Zooplankton consist of Crustaceans, Rotifera and Protozoa. The number of Protozoa is greater than others due to its ability to withstand a deteriorating environment by forming cysta and being able to utilize organic matter (detritus), other organisms, substances that dissolve as foodstuffs and have a shorter reproductive stage than other classes [5]. The role of Crustacea in the waters as feed for larvae and fish [29,30]. The value of diversity in general with a value between 1<H' (Shannon-Wiener) <3 (Figure 6) informs the level of moderate was spread, water productivity is sufficient. Swamp water ecosystems are in stable condition with moderate ecological pressures, so no species dominate or minority at the study area. Plankton diversity did not differ significantly in all locations and still falls into moderate categories of communities [31].

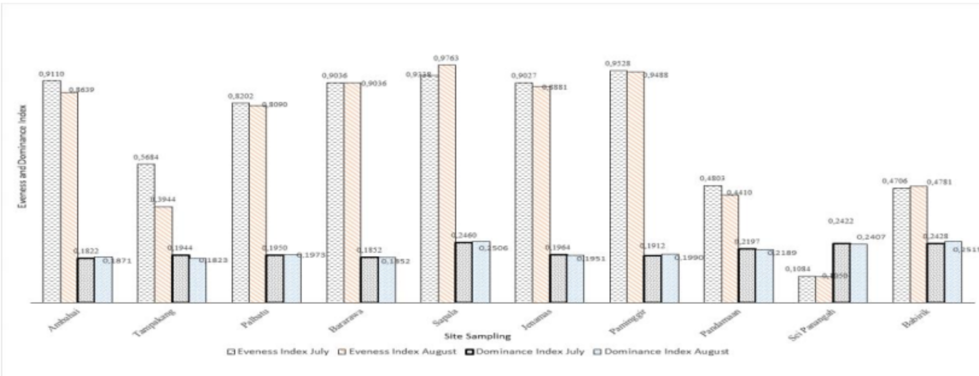

Figure 5. Evenness and Dominance Index of phytoplankton.

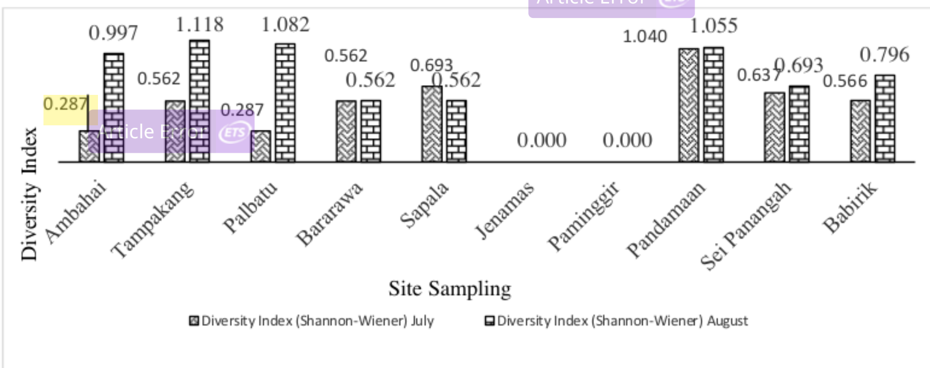

Figure 6. Diversity index of zooplankton

The value of zooplankton Evenness with ranged value > 0-1 (Figure 7), indicated that the distribution between genera is relatively uniform or the composition of the number of individuals of each genera was relatively the same, there is even one species. While from the dominant index value of 1 (Figure 7) means there was a type that dominates [32,33]. Zooplankton was found fewer than phytoplankton, therefore zooplankton are suspected to have not utilized phytoplankton optimally. Many zooplankton can perform vertical migration movements. Such patterns of movement cause differences in abundance and composition of zooplankton. The production rate of zooplankton is lower than phytoplankton (Figure 6 and 7), so the peak of zooplankton production was lower and occurred after the peak of phytoplankton.

In general, nitrate concentrations in waters with good condition (uncontaminated pollution) were in the low range of 0.13 – 0.25 mg/l, while phosphate ranged 0.12 - 0.52 mg/l (Figure 8). The optimal phosphate content for phytoplankton growth was in the range of 0.27-5.51 mg/l and will be a limiting factor if less than 0.02 mg/l. Nitrates are the main form of nitrogen in natural waters and are the main nutrients for plant and algae growth. The increase in nitrate levels occurs due to the influence of run off from agricultural areas, density of aquatic plants, rivers and settlements of the land around the swamp. The presence of phosphorus in natural waters is usually relatively smaller, and the levels are less than in nitrogen levels. Phosphorus is an essential nutrient for high-level plants and algae because the source is relatively few, phosphorus becomes a limiting factor in the waters.

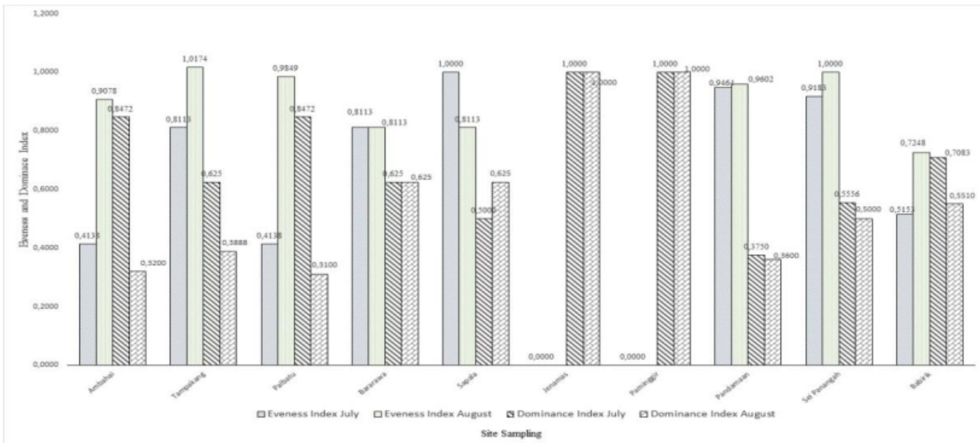

Figure 7. Evenness and Dominance Index of zooplankton.

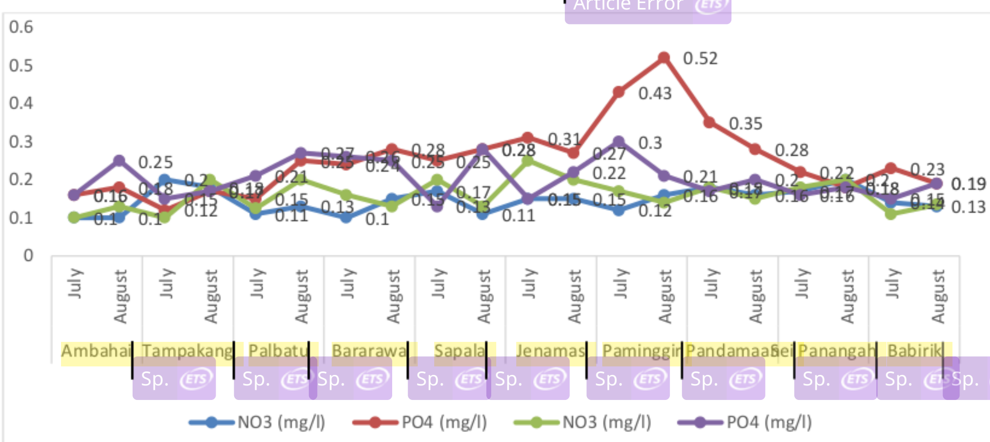

Figure 8. Nitrate and phosphate concentration.

Nitrates and phosphates are the dominant nutrients found in a water used by phytoplankton and other biota in food chain processes [1]. The basic ingredients of protein makers are taken by aquatic plants in the form of ammonia or nitrates [34]. Nitrates are an important nutrient component for plants and algae which is indirectly a consumption for carnivorous fish. Nitrate and phosphate values from all observation sites ranged from 0.1- 0.2 mg/l belonging to the mesotrophic category. Nitrate and phosphate components are not affected by inundation typology patterns and plankton composition [35][36]. Low water mass exchange results in a build-up of nitrate and phosphate concentrations in swamp waters and can ultimately degrade the quality of the waters.

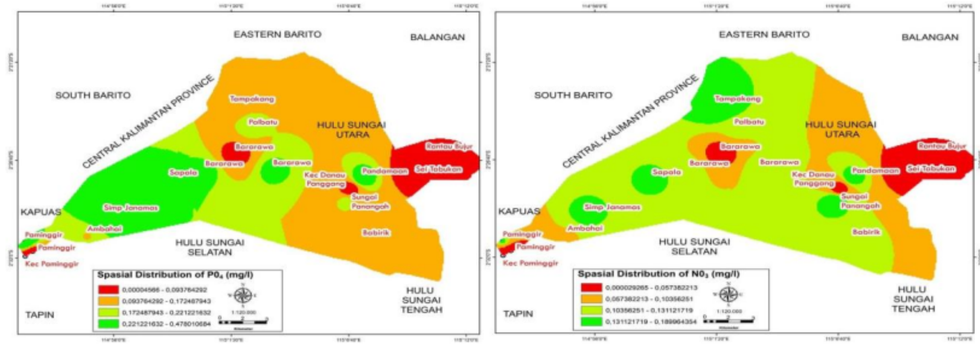

Figure 9. Spatial distribution of nitrate and phosphate.

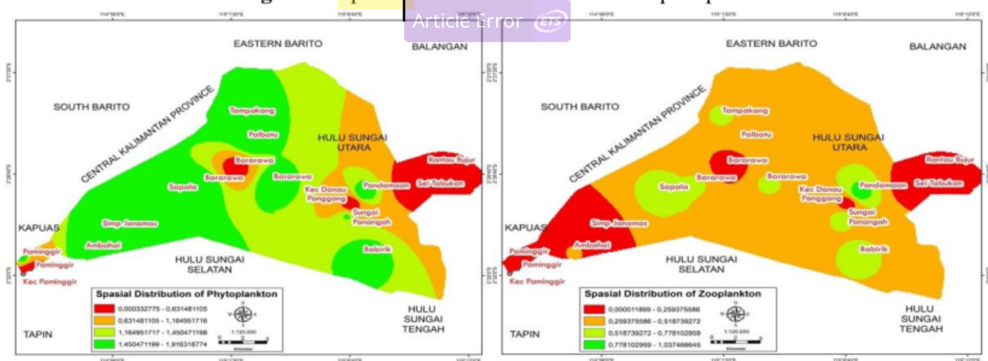

Figure 10. Spatial distribution of phytoplankton and zooplankton

The spread of nitrates and phosphates was low in the south (Figure 9) especially in the Tabukan River area. Groups of phosphates and nitrates are found high in the central part of the water, but nitrates are scattered spot-by-spot in the areas of Jenamas, Sapala, Pandamaan and Tampakang. The distribution spatial of phytoplankton and zooplankton spatial were completed using spatial interpolation (inverse distance weighting/IDW) with a search radius using variable methods, and a cell size of 0.010 (100 meters). Ten stations were used to assess the accuracy of the model. Both phytoplankton biomass models and zooplankton biomass had performance with high accuracy. IDW spatial interpolation as part of deterministic interpolation that calculates from the closest measured point and exerts the most influence, the distance of each sampling point plays an important role in building a high accuracy model [37,38]. The distribution of plankton was influenced by the sampling density and distance of each sampling station. Spatial analysis of plankton distribution in this study showed that both phytoplankton and zooplankton were lower in the Tabukan River area. The abundance of zooplankton (Figure 10) was low in the west or estuary of large rivers which contributed to inundation in swamp ecosystems. The optimal concentration of zooplankton abundance in the central part of the study area could be developed for inland fisheries with cultivated of predatory fish *(Channa and Anabantidae)*. Optimal phytoplankton located in the western part could be used for the cultivation of economical planktivorous fishes. Phytoplankton biomass is a strong predictor for zooplankton biomass modeling, spatial model phytoplankton encourages the distribution of zooplankton biomass and trophic level response of swamp fisheries. Reduced zooplankton biomass components can be used as ecological predictions of fish habitats in critical conditions [39-42].

4. Conclusion

Type of phytoplankton found in the waters of the Swamp Paminggir consisted of, class Bacillariophyceae (9 genus), Chlorophyceae (6 genus), and Cyanophyceae (3 genus). While the types of zooplankton found were Rotifera, Protozoa and Crustaceae. Diversity index of phytoplankton in the waters in the Swamp Paminggir was classified as moderate because the value of diversity ranged 1.504 - 1.917. Evenness and dominance index of phytoplankton were <1. The production rate of zooplankton was lower than phytoplankton. Nitrates were still low and phosphate optimal for support growth of phytoplankton and suitable for inland fisheries.

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Missing "," Review the rules for using punctuation marks.

Wrong Article You may have used the wrong article or pronoun. Proofread the sentence to make sure that the article or pronoun agrees with the word it describes.

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S/V This subject and verb may not agree. Proofread the sentence to make sure the subject agrees with the verb.

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Prep. You may be using the wrong preposition.

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Verb This verb may be incorrect. Proofread the sentence to make sure you have used the correct form of the verb.

Article Error You may need to use an article before this word. Consider using the article **the**.

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Proper Nouns You may need to use a capital letter for this proper noun.

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Confused You have used either an imprecise word or an incorrect word.

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Proofread This part of the sentence contains an error or misspelling that makes your meaning unclear.

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