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Spatio-temporal distribution of phytoplankton in the Maralol and Salawatlol River on Salawati Island, Sorong Regency, West Papua

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Spatio-temporal distribution of phytoplankton in the Maralol and Salawatlol River on Salawati Island, Sorong Regency, West Papua

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Abstract. Maralol and Salawatlol River in southern Salawati Island, Sorong, West Papua receive tile as waste of upstream mining activities. The organic and inorganic materials in the waste could influence community structure of phytoplankton. The aim of this research was to study the relationship between plankton community and water quality. Research was conducted from 2010 to 2015 with six months sampling interval at ten sites that was separated into two temporal group. Spatial analysis was conducted to map the distribution pattern of plankton using ArcGIS 10.1 with IDW (Inverse Distance Weighted) interpolation method. There were 65 genera from six groups of phytoplankton community in Maralol River and 44 genera from five groups in Salawatlol River. There was different dominant phytoplankton group of each river at the first temporal cluster Chlorophyceae in Maralol and Cyanophyceae in Salawatlol. Furthermore, the dominant group at the second period was Cyanophyceae. The β diversity value in Maralol showed turn over condition or more variative than the Salawatlol that showed a nestedness condition. As a whole, the community of phytoplankton was highly correlated to several parameters of water quality, the TSS and dissolved inorganic nitrogen.

1. Introduction

Watersheds are areas that join a river, which function to accommodate, store, and drain air from rainfall to the sea [1]. The condition of river water as lowest area is highly correlated to the watershed [2]. River roles to nutrient transportation to downstream area [3].

Maralol River (27.54 km) and Salawatlol River (19.27 km) are located in the southern part of Salawati Island, Sorong Regency, West-Papua [4]. This area receives liquid waste from oil and gas mining activities on Salawati Island. The liquid waste comes from produced water and rainwater runoff in oil wells; which contains residual oil in the form of droplets that are spread in water, some solid materials, small amounts of dissolved hydrocarbons, and gases [5] .

Maralol River receives the liquid waste, directly, while Salawatlol River mostly receives input from run off basin and upstream, and influenced by rivermouth condition. Rivers are covered by riparian vegetations. Leaf drop from the vegetation can cause changes in water quality.

Produced water and runoff of rainwater that enters the two rivers has the potential to be a source of input for organic and inorganic materials that can affect the quality of river waters. The change of water quality could influence phytoplankton community. The community has specific tolerance towards water quality which related to its composition and density. The dynamic of input into waters will effect the phytoplankton community. Furthermore, the different input of the two rivers will show different this community. Meanwhile, there are lack information about phytoplankton community of river ecosystem, especially with produced water input. The aim of this research was to study the relationship of plankton community and water quality.

2. Methods

2.1 Data collection

The data of phytoplankton and water quality were collected from observation on two sampling sites of Salawatlol River and eight sites of Maralol River (figure 1). The samples were taken two times in one year, from 2010 to 2015.

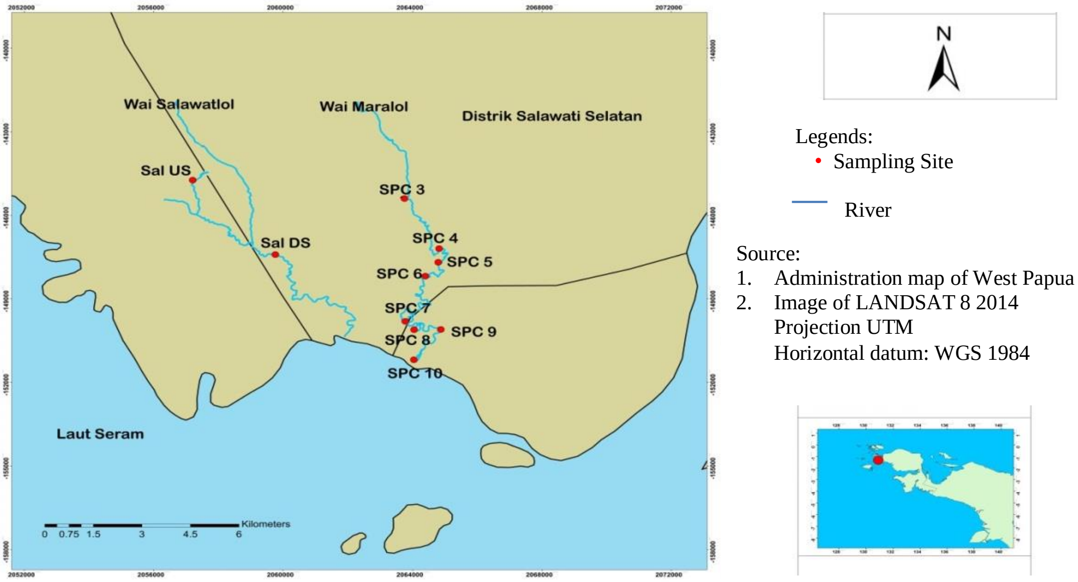


Figure 1. Sampling Site of Maralol and Salawatlol River.

2.2 Data analysis

There were several similarity analysis to develop temporal and spatial cluster using Bray-Curtis Index [6] based on phytoplankton density. For each cluster, there will be calculated biological index, such as Shannon-Wiener Diversity Index, Eveness Index [7], and Simpson Diversity or Dominance Index [8]. Spatial analysis was conducted to map the distribution pattern of plankton using ArcGIS 10.1 with IDW (Inverse Distance Weighted) spatial interpolation method. Furthermore, in order to understand the spatial variation or inter-cluster of phytoplankton diversity, there is a specific calculation of β Diversity Index, based on phytoplankton richness. The calculation of β Diversity Index starts with the determination of richness of each cluster (α), follows by the total richness of phytoplankton (γ) [9]. The difference diversity of in-between cluster (β) is calculated from the formulations [9] below :

$$\beta_{-3} = \left[\frac{\min(b,c)}{(a+b+c)}\right] \quad \text{.....................} \quad (1)$$

$$\beta_{rich} = \left[\frac{(b-c)}{(a+b+c)}\right] \quad \text{.....................} \quad (2)$$

$$\beta_{cc} = \left[\frac{(b+c)}{(a+b+c)}\right] \quad \text{.....................} \quad (3)$$

$$\beta_{cc} = \beta_{-3} - \beta_{rich} \quad \text{.....................} \quad (4)$$

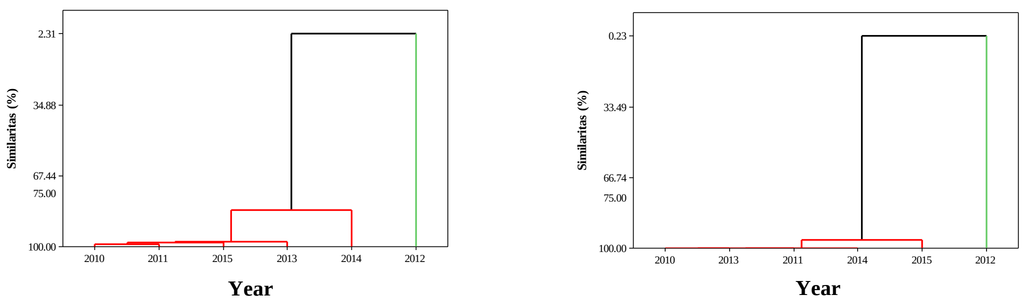
with:
βcc : Difference of total inter-cluster diversity
β-3 : Inter-cluster turnover
βrich : Inter-cluster nestedness
a : Number of species found in both cluster
b : Number of species found in the first cluster
c : Number of species found in the second cluster

The cluster were grouped based on specific characters of water quality and phytoplankton density. Pearson correlation test was used to study the relationship between phytoplankton density and water quality [10].

3. Result and discussion

3.1 Result

Cluster analysis of Maralol River were performed for phytoplankton and water quality. However, the analysis for Salawatlol River was performed only for phytoplankton density. The temporal cluster was shown in figure 2 (a and b). There were two temporal groups in both river. First group consists of five sampling periods, exclude 2012 that was grouped as the second group.
Furthermore, based on the first temporal cluster, there were four spatial clusters (Station SPC3, Station SPC4, 5, 6, 7, 8, 9, and Station SPC10). Based on the second temporal cluster there were two spatial clusters (Station SPC 10, and others) of Maralol River. Then, for Salawatlol River, there were two spatial clusters (Station Sal US and Sal DS, separately) for both temporal cluster.



(a) (b)

Figure 2. Temporal cluster (a) Maralol River (b) Salawatlol River.

3.1.1 Phytoplankton composition.

There were six classes of phytoplankton at the first temporal cluster and five groups at the second temporal cluster of both river. figure 3 shows the proportion of phytoplankton density.

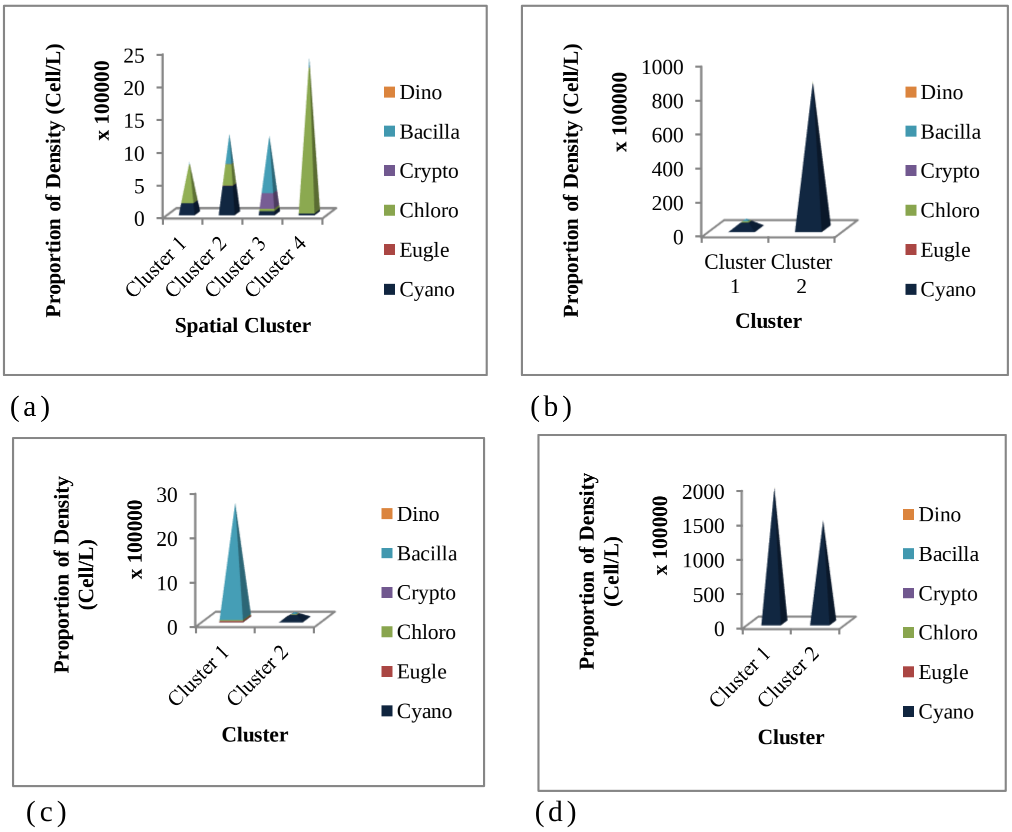


Figure 3. Proportion of phytoplankton density at two temporal clusters of Maralol and Salawatlol River; first temporal cluster(a & c), second temporal cluster (b & d).

There are two temporary types of phytoplankton community performance of both rivers. The first is a variative composition in the first temporal cluster, and homogenous composition in the second temporal cluster. There were still appeared dominance at the first temporal cluster. Chlorophycea was dominance in Maralol, while Cyanophyceae in Slawatlol. Then, the dominant group at the second period was Cyanophyceae.

3.2 Discussion

The distribution of density, dominance, and diversity of phytoplankton are shown in figure 4. He The higher density was found in upper part of the rivers. Meanwhile, tthe higher dominance index was found in lower part of the rivers.

There were different dominant species in different temporal cluster. Chlorophyceae, especially Spirogyra sp., and Bacillariophyceae, especially Melosira sp., were dens at the first temporal cluster. The density of both species were 4×105-21×105 cell/m^3 and 3×105-8×105cell/m^3,respectively. Furthermore, especially Oscillatoria sp. Was dominant at the second temporal cluster by 2×106-84×106 cell/m^3.

The diversity of phytoplankton is shown in Table 1. Based on Table 1, it is shows different condition between the two temporal clusters. The H’ values were relatively low, but high values of Dominance Index were appeared in second temporal cluster. It shows that Maralol River has more variative phytoplankton than Salawatlol River.

The difference of diversity, both spatially and temporaly, was consequence of different number and density of phytoplankton species whish was correlated to water quality. High density of one species showed a dominance, and lowering the value od diversity index.

(a)	(b)	(c)
Legends:	Legends :	Legends :
: 15316	: 0.21-0.41	: 0.00-0.46
: 30026	: 0.41-0.61	: 0.46-0.92
: 44737	: 0.61-0.80	: 0.92-1.37
: 805	: 0.81-1.00	: 1.37-1.83

Figure 4. Distribution of phytoplankton in Maralol and Salawatlol River; (a) total density, (b) dominance, (c) diversity.

Table 1. Diversity of phytoplankton at Maralol River (a) and Salawatlol River (b).

(a)	Indeks	Temporal Cluster	
		1	2
	Diversity (H')	0.52-2.10	0.13-2.04
	Eveness (E)	0.14-0.55	0.04-0.54
	Dominance (C)	0.18-0.83	0.25-0.96
(b)	Indeks	Temporal Cluster	
		1	2
	Diversity (H')	0.71-1.28	0.07
	Eveness (E)	0.21-0.43	0.02
	Dominance (C)	0.49-0.66	0.98

Table 2 and 3 show inter-cluster diversity value of phytoplankton of Maralol and Salawatlol River. Most of phytoplankton of Maralol River indicated turn over condotion, while from Salawatlol tents to be nested.

The value of turnover (β-3) and total richness (γ) in Maralolwere relatively higher than Salawatlol River. It means that the phytoplankton community was variative. Turn over oftenly caused by the change of environmental condition [11].

Table 2. Inter-cluster diversity in Maralol River.

α cluster 1				α cluster 2	
α1	α2	α3	α4	α1	α2
25	45	35	38	43	19

Diversitas β	α1 & α2	α1 & α3	α1 & α4	α2 & α3	α2 & α4	α3 & α4	α1 & α2
βcc	0.571	0.571	0.600	0.462	0.491	0.510	0.591
β-3	0.163	0.333	0.311	0.269	0.364	0.449	0.045
βrich	0.408	0.238	0.289	0.192	0.127	0.061	0.545

Table 3. Inter-cluster diversity in Salawatlol River.

	α cluster 1		α cluster 2	
	α1	α2	α1	α2
	30	19	25	19
Diversitas β	α1 dan α2		α1 dan α2	
βcc	0.559		0.370	
β-3	0.235		0.148	
βrich	0.324		0.222	

The more variative species in Maralol River was influenced by the high material input from produced water, while Salawatlol River was only received rain water and run off. The produced water is a mixture of organic and anorganic component that will support nutrient into the water [12].

Water quality, especially TSS and nutrients of Maralol and Salawatlo River were relatively higher in second temporal cluster. The distribution of TSS and nutrients are shown in figure 5.
The low or high density of phytoplankton related to TSS condition. The low level of TSS influenced the high penetration of light into the water, vice versa [13].

The high nutrient value, generate some species of phytopLankton, such as Melosira sp. Melosira sp. is commonly found in eutrophic waters [14-16]. The high nutrients condition was also cause the high density of Oscillatoria sp. From Cyanophyceae [17,18].
Anthropogenic activities could increase organic and inorganic materials that produce available nutrients into waters. As consequence, it will lead eutrophication process and changes the trophic states of waters to the higher level [14, 18] . The high level of trophic states of Lido was indicated by the domination of *Melosira* sp.

Based on all information about phytoplankton densities and water quality, the result of Pearson correlation test showed the significant influence of water quality towards phytoplankton community. It was shown that the phytoplankton has a highly correlated to TSS and nitrogen. Hidrodynamic condition, especially water current, influences density and composition of phytoplankton [19]. As shown in this study, the density and diversity of phytoplankton was relatively low. It is assumed that although the community was influenced by nutrient within material transport, it was also inluenced by suspension particle that inhibited light penetration.

Legends:
: 11.00-13.25
: 13.25-15.50
: 15.50-17.75
: 17.75-19.99

Legends :
: 0.10-0.12
: 0.12-0.14
: 0.14-0.16

Legends :
: 0.05-0.20
: 0.20-0.36
: 0.36-0.52
: 0.52-0.68

Figure 5. Distribution of water quality and nutrients in Maralol and Salawatlol River; (a) TSS, (b) nitrate, (c) total phosphate.

On the other hand, there was a unique condition, with the presence of filamentous alge beds along the shallow part of Maralol River. It seems that other causes of low density of phytoplankton is the high utilization of nutrients by the filamentous algae community.

4. Conclusion

The community of phytoplankton was highly correlated to several parameters of water quality, the TSS and dissolved inorganic nitrogen, that showed different dominance and spatial distribution pattern in Maralol and Salawatlol River.

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