RESEARCH ARTICLE

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The Differences in Phytoplankton Community Structure of Pond Waters Between Pemalang and Brebes, Central Java, Indonesia

Benny Diah Madusari[1,*], Jafron Wasiq Hidayat[2,*], Dwi Edy Wibowo[3], and Chalimah Muhammad[4]

[1]*Fisheries Faculty, University of Pekalongan, Pekalongan, Central Java, Indonesia*
[2]*Biology Department, Faculty of Science and Mathematics, Diponegoro University Semarang, Central Java, Indonesia*
[3]*Low Faculty, University of Pekalongan, Pekalongan, Central Java, Indonesia*
[4]*Economy Faculty, University of Pekalongan, Pekalongan Central Java, Indonesia*

Nowadays, the most of water bodies tend to be depleted and it should be monitored and managed in an integrated manner, mainly on its biotic resources. This study aimed to identify the structure of plankton (diversity), to analyze the similarity and depletion potential due to cultivation practice. Research was done through sampling method in two different localitions of coastal waters, i.e., Pemalang (practicing in isolated pond dike) and in Brebes with no permanent dike condition. Data collection was done through sampling using plankton net taken at six stations. Data analysis used were species diversity index (H') and the evenness index (e) as well as Sorensen Index (*SI*). Data were also to be analyzed in term of feasibility aspects of cultivation using Saprobic index. Results showed that the planktonic structure of these two locations expressed with H' index is different, where in Pemalang it is about 1.91–1.46 range, whereas in Brebes it is about 2.0–2.39 range. These two ranges of H' indices values were categorized into low stabilities of the pond community. This situation was affected by cultivation practices, especially by the associated intensive system. The intensive cultivation has been successfully adopted in Pemalang by applying geo-membrane and chlorine for water treatment processes. The dominant species of the two locations aforementioned were *Lyngbia* sp and *Surirella* sp. *Thallasiothrix* sp was dominance only in Pemalang and it was replaced by *Melosira* sp in Brebes. Saprobic index showed that its value was 0.8–1.8 range, a moderate high category (beta-*Mesosaprobic*/*oligosaprobic*) up to aOligo/Beta *mesosaprobic*. In term of nutrient enrichment of the water, such water quality was classified as polluted waters in particularly as light to moderate polluted water due to organic and inorganic components.

Keywords: Community Structure, Plankton, Saprobity Level, Similarity Index.

1. INTRODUCTION

Phytoplankton is the primary production in aquatic ecosystem.[1] The abundance of phytoplankton is determined by the nutrient availability, sunlight sufficiency and water movement. An important component affecting the plankton abundance is pollutants,[2] mainly the ones sourced internally from aquaculture practices either un-consumption residual feed or discharge of metabolic processes. Water enrichment will cause phytoplankton bloom and it will reduce water quality. Conversely, if water is poor in nutrients, then phytoplankton would be less abundance and so less available to feed cultivated fishes. Poor water management can lead to affect water quality, feeding patterns of cultivated biota, health of the food and biomass crops.[3] One important resource to be managed to maintain water quality is plankton, a primary production on water bodies.

Plankton in brackish water has little diversity due to drastic in physical and chemical conditions.[4] The dominant phytoplankton in brackish waters is Chrysophyta whereas zooplankton is Crustacea.[2] An abundance of plankton species is inversely proportional to zooplankton diversity.[4] Plankton is an organism that also can serve as bio-indicators of pollution. If coastline has not been contaminated so there is a balance plankton quality and even number of plankton species that are toxic.[5,7]

In north coast of Central Java, most waters are used for fish, shrimp and seaweed cultures both monoculture and poly-culture (small portion is practicing for salt production during dry season). Water quality there is affected by many anthropogenic inputs (wastes), such as industry, settlement (domestic), transportation and fishery. Most of cultivate practices provide additional/artificial feed(s) which potentially increase pollutant to the water body.[6] Ponds tend to decreased its water quality over time and lead to deplete the fish quality. Therefore, its necessary to run research on water quality in different localities based on

*Authors to whom correspondence should be addressed.

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biotic factors, especially its community structure of plankton. This study intended to analyze the diversity of plankton, especially to determine the changes in quality of the aquatic environment. This was also to compare between the diversity of plankton in the surrounding water and locations.

2. EXPERIMENTAL DETAILS

The study was conducted in two locations, i.e., coastal waters of Pemalangand Randusanga Brebes. Both localities have an active in fish culture practice and community (farmers) groups (culture and production). The research was conducted in June 2016. Plankton and physic-chemical analysis were done in the Laboratory of Ecology and Biosystematics, FSM Diponegoro University as well as Wahana Laboratory, Semarang.

Data were taken through sampling method in six different waters of two localities. Location was selected to represent the variability of the environment, covering public irrigation water body, water of the pond as well as semi-intensive pond. The pond water body consists of conventional pond (with embankment) and modern ponds, i.e., geo-membrane and netted (without dike) ponds. Plankton net (no. 25) was used to sieve plankton that equipped with 80 ml collected bottle. Water of 30 liter was sieved to be 80 ml on the collection bottle. The physic-chemical parameters were also measured include; temperature, water clarity, salinity and acidity. Plankton enumeration and identification was done to determine their structure. Descriptive and mathematical analysis were used, including Biodiversity Shannon-Wiener Index (H'), evenness index (e) and Similarity Index (SI). Saprobic index was implemented to analysis the fertility of the waters, as done by Basmi.[7] The detailed analysis of the index was as follows:

Diversity Index (H'): Species diversity index used was Shannon-Wiener diversity index.[8] The formula was as follow:

$$H' = -\sum (n_i/N)\ln(n_i/N)$$

Where: H' = diversity index of Shannon-Wiener, n_i = number of individuals of species i, N = total number of individuals of all species.

Evenness Index (e): Evenness index used was:

$$e = H'/\ln S$$

Where: e = evenness Index, H' = diversity index of Shannon-Wiener, S = number of species.

Dominance Index: Dominance Index used was:

$$D_i = n_i/N \times 100\%$$

Where: D_i = relative density index of species i, n_i = number of individuals of species i, N = total number of individuals of all species.

According to Krebs[8] to describe the dominant species was:

- Dominant species, $D_i \geq 5\%$
- Subdominant species, $D_i = 2$–5%
- Non-dominant species, $D_i = 0$–2%.

Saprobic Analysis: To identify the environment quality based on life plankton it can be used saprobic coefficient. Saprobic coefficients used were Dresscher and Van Der Mark equation,[7] calculated by the following formula:

$$X = \frac{C + 3D - B - 3A}{A + B + C + D}$$

Where: X = Saprobic Coefficient, between of -3 to $+3$, A = Number of species groups Cyanophyta (Polisaprobic), B = Number of species groups Euglenophyta (α-Mesosaprobic), C = Number of species groups Chloroophyta (β-Mesosaprobic), D = Number of species groups Crhysophyta (Oligosaprobic).

3. RESULTS AND DISCUSSION

3.1. Biodiversity of Plankton in Pemalang and Brebes Coastal

The result of observations showed that diversity of plankton on both coasts were likely to be small in index (H') between 1,46–2,35. Data of those H' values were illustrated in Table I. This value is lower than the H' index value in Wedung, Demak coastal which ranged from 1,69 to 2,91.[9] Hudaidah[3] also obtained a low diversity in Lampung waters, which ranged from 1,16 to 1,71. These lower of value in Pemalang and Brebes were indicate small stability of the ecosystem. According to Odum[4] stability of the communities associated with complexity of the food chain. A more stable status means more complex in food chain. Such a lower range of values in current findings were related to human activities which tend to be high around farming activities, including pond preparation, cleaning up the ponds environment, releasing juvenile, pond maintenance, especially feeding. Beside, most of the plankton is also grazed by cultivated fishes or others, so the occurrence of fish will also reduce the diversity of plankton.

Diversity status in Pemalang waters was smaller with H' index ranged between 1,46 to 1,91 while in Brebes waters was a little higher between 2 to 2,35. The lowest diversity was found in Pemalang, namely in the intensive pond which applying sterilization of pond water and the use of plastic layer (geo-membrane). Sterilization of water is done using chlorine to reduce fouling organisms,[6] this unfortunately can affect almost all planktons in the surrounding water. Apart from geo-membraned pond, most of the ponds in Pemalang are still use the conventional method,

Table I. Diversity and abundance of plankton in coastal waters of Pemalang.

		Number of individual/L in station		
No.	Species	Public irrigation water	Intensive pond water	Traditional pond water
A	Bacillariophyceae			
1	*Asterionella* sp	102	17	17
2	*Surirella* sp	119	17	68
3	*Rhizosolenia* sp	85	0	0
4	*Tabellaria fenestrate*	17	0	0
5	*Thalassiothrixnitzchioides*	238	323	34
B	Chlorophyceae			
6	*Closteriummoniliferum*	51	51	0
7	*Monoraphidium* sp	0	17	0
C	Cyanophyceae			
8	*Lyngbyaconfervoides*	255	187	119
D	Dinophyceae			
9	*Ceratiumhirundinella*	0	17	68
10	*Dinophysismitra*	0	0	34
11	*Dinophysis* sp	102	51	170
	Total individual (N)	969	680	510
	Total species	8	8	7
	Diversity index (H')	1,91	1,46	1,72
	Evenness index (e)	0,92	0,70	0,88

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in which the H' index value was slightly better than membraned one, reaching 1,72. The H' index value on irrigation waters and traditional ponds were relatively better even thought only reaching a value of 1,91. This can be assured that aquaculture activities (milkfish and shrimp) contribute to the decline in plankton diversity through depleting water quality and grazing action.

In Brebes waters, diversity index (H') is higher especially in public irrigation waters around the pond which varies between 2 to 2,35. Such a condition is better which associated with the openness of water. Most of Brebes pond in coastal area has experienced drownings and loss of functional dikes. Most people in Brebes no longer keep the fish in the isolated pond (with a permanent dikes) but applying nets to keep (isolate) the fishes. In this case, the water are easily coming in and out. Therefore the plankton also follow the dynamic of the water, without significant grazing in an isolated column. The diversity and abundance of the plankton is mentioned in Table II.

3.2. Plankton Abundance in Coastal Waters of Pemalang and Brebes

Observation of plankton abundance and diversity showed that species found in the waters of Pemalang there were 11 species, while in the waters of Brebes reached 12 species. The most common species found in Pemalang coastal waters were *Thassiothrixnitzchioides*, *Lyngbiaconfervoides* and *Dynophisis* sp with the abundance respectively reached 323, 255 and 170 individual/lt (Table I). Another abundance species were *Nitzchia* sp and *Surirella* sp that found only in irigation waters and very rarely found in the pond water. *Nitchia* is a species commonly found in a little extreme waters, including in environments containing salt.[10] In plastic geo-membraned practice, these were also became dominant species. This is different to findings of Hudaidah[3] in South Lampung in which *Ghompospaeria* sp, sp *Chaetosheros*, and *Chlorella* sp were the dominant. This is probably related to nature of brackish water there and predation pattern by cultivated fishes, especially white shrimp *Lithopeneausvannamae*. Shrimp and fish consume plankton as natural food, especially at a young stage.

The abundance of plankton in Brebes showed slightly different and found 12 species (Table II). The most common species were *Melosari* sp, *Lyngbya* sp *Surirella* sp. *Lyngbia* sp is a species that is also commonly found in both coastal waters. The other species dominant in both waters were *Rhizosolenia* sp and *Dinophysis* sp. Dinophysis is a group Dinoflagellata which usually being avoided to appear in the pond.[1,7] This species tends to grow fast on the nutrient enriched water and does resistant to low salinity conditions. In shrimp farming, the preferred dominance plankton is Chlorophyceae or Bacillariophyceae with the dominance of >90%, while Cyanophyta should be <10% and Dinoflagellata <5%.[7] Referring to these criteria, then in both locations Dinoflagellata abundance tends to be high and must be managed carefully. Most of the members of Dinoflagellatais enable to produce toxic, harmful to aquatic and cultivated fish and humans.[2] Enrichment of waters should be done to diminish Dinoflagellata. The reduction can be done using nutrient-absorbing agent, including seaweed (aquaculture) to catch up such nutrients can be converted into biomass seaweed.

Table II. Diversity and abundance of plankton in coastal water of Brebes.

No.	Species	A number of individual/L	B number of individual/L	C number of individual/L
A	Bacillariophyceae			
1	*Fragilaria* sp	17	0	0
2	*Gyrosigma attenuatum*	51	85	119
3	*Melosira* sp	102	255	136
4	*Rhizosolenia* sp	34	85	119
5	*Surirella* sp	51	323	136
6	*Synedra* sp	85	68	17
B	Chlorophyceae			
7	*Cladophora*sp	34	68	119
8	*Stigeoclonium puscheri*	34	0	0
C	Cyanophyceae			
9	*Lyngbya confervoides*	85	136	136
10	*Oscillatoria formosa*	51	68	51
D	Dinophyceae			
11	*Dinophysis norvegica*	85	272	187
12	*Pyrocystis nocticula*	17	0	0
	Total Individu (N)	646	1360	1020
	Total Species	12	9	9
	Diversity Index (H')	2,35	2	2,09
	Evenness Index (e)	0,94	0,91	0,95

Note: A = Public irrigation waters, B = Monoculture pond, C = Polyculture pond.

3.3. Conditions of Physical and Chemical Factors at Pond Water

According to Trobajo et al.[10] typical of the pond water is its dynamic salinity and temperature that can be quickly changed. Temperature in Pemalang pond is ranges between 29–33 °C. According to Setiawan,[11] the survival of phytoplankton ranged between 20–30 °C. The photosynthesis performance of the phytoplankton is commonly not optimal in high temperature condition. The degree of acidity (pH) in the Pemalang and Brebes pond were tend to acid with values respectively from 5,3 to 6,3 and from 5,5 to 6,5. According to Diansyah,[12] normal pH ranges of the plankton are 6,5 to 8,5. Measurements of average clearness in Pemalang were 21–25 cm and in Brebes were 23–40 cm. Both include a lower clearness for less than the normal value of the standard which were between 30–40 cm. The clearness of the waters is affected by tidal action/level. Physical and chemical factors were mentioned in Table III.

3.3.1. Quality of the Water Fertility

Result of saprobic analysis showed that saprobic index values ranged from 0,8 to 1,8 with a rather high qualification (beta-Mesosaprobic/oligosaprobic) up to Oligo/Beta mesosaprobic. Quality of water fertility was included polluted between the very light to mild, with components of organic and inorganic

Table III. Conditions of physical and chemical factors at two pond location.

No.	Parameter	Range of the parameters value at sampling location: Pemalang	Brebes	Standard reference value
1.	DO (mg/l)	5,3–6,1	4,0–5,4	>5
2.	Temperatur (°C)	29–33	28–32	20–30
3.	Salinity (ppt)	27–30	24–30	5–30
4.	pH	5,0–6,3	5,5–6,5	6,5–8,5
5.	Clearness	21–25	23–30	30–40

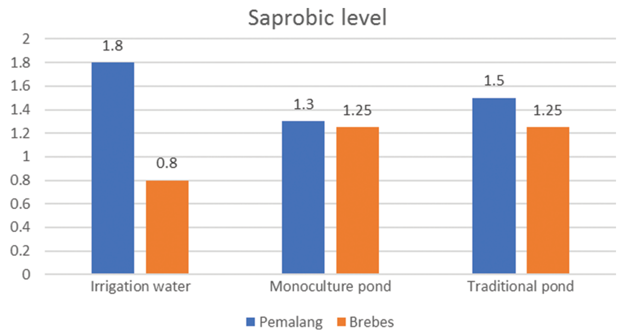

Fig. 1. Saprobic level of pond waters in Pemalang and Brebes.

pollutants. These contribute to both sedimentef and suspended ones to form POM (Particulate Organic Matter) portion. In term fertility and potential contamination, water quality in Brebes was better than Pemalangs'. This is consistent with the quality index of diversity (H'). The range of index values saprobic in Pemalang ranged from 1,3 to 1,8 with the qualification of very lightly to mild polluted. In Brebes the index is slightly more fertile waters where it is associated with openness of tidal freely supplying nutrients into the pond. The cultivation activities surely contribute to nutrient enrichment for both locations. This was consistent to these above discussion, i.e., diversity and abundance indicators. Values of the index was mentioned in Figure 1.

4. CONCLUSIONS

The pond community structure of the both Pemalang and Brebes plankton expressed with H' index is different, where in Pemalang it is about 1.91–1.46 range, whereas in Brebes it is about 2.0–2.39 range. The dominant species of the two locations were *Lyngbia* sp and *Surirella* sp. However *Thallasiothrix* sp was dominant in Pemalang and majority of *Melosira* sp exist in Brebes. Similarity index value of Sorensen formula was 34.78%, it means the two regions is different in plankton composition. In addition, Saprobic index was 0.8–1.8 range; a moderate-high category (beta-*Mesosaprobic/oligosaprobic*) until an Oligo/Beta *mesosaprobic*.

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