The water quality and Cultivant enrichment potency of pond based on saprobic index at north coastal waters of Central Java, Indonesia

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Abstract. Central Java is one of many areas which has long coastline, especially in the Northern Coast of Java Island. Intertidal activities occurred at this area may affect the transport of material and energy from surroundings. Cultivation activity supplies many inputs, i.e. feeds, chemicals (vitamin and mineral), including pollutants from feces and unconsumed feeds that affects the environment. One of water management is done through bioremediation by using vegetative agents (soft rehabilitation), such as seaweed and mangrove stands. The implementation of soft rehabilitation is highly depend on the existing environmental conditions of the ponds and surrounding waters. Therefore, it is very important to identify the condition of those waters first. The purpose of this study is to identify the quality of waters in the north coast of Central Java. Besides, it is also to analyze the potency of enriching cultivated commodity (cultivant), as well as a soft remediation mechanism using seaweed. The study was conducted in the coastal areas of Central Java, mainly to the locations commonly practicing cultivation in the pond waters; namely Brebes, Pemalang, Semarang, Demak, Pati and Jepara. Data were taken by sampling at least at 3 different sites as repetition, included ponds, public irrigations and coastline waters. The water sample was taken as much as 30 lt and filtered using plankton net no 25. Biodiversity of Shannon-Wiener Index (H'), evenness index (e) and Saprobic Index were used to analyze the plankton data. Result showed that plankton diversity in Central Java coasts were varied generally between 10 – 28 species. The most widely found species were Oscillatoria sp, Rhizosolenia styliformes, Surirella sp and Lyngbia conferoides. The diversity index varied from 1.83 to 2.9 with the stability status were between small to medium. The saprobic index showed a value between 0.33 up to 2.27; which indicated very small up to lightly contaminated status. The biggest stability disturbance was found in Batangan (Pati) water, especially because the existence of salt production practice in the pond during dry season. The optimum polyculture practice was found in Brebes, since this water was still suitable to support aquaculture in multitrophic basis, so called IMTA (Integrated Multitrophic Aquaculture). In general, the other pantura waters were still liable to be enriched with other cultivants, including seaweed which is also economically valuable (as a commodity) and also ecologically functional in controlling turbidity and contamination.

Keywords: Plankton, pond water quality, cultivant enrichment, north central Java coasts

1. Introduction
Aquaculture contributes greatly to the national economy of Indonesian and should be developed continuously. Most of the cultivation practices are done in the coastal areas, especially around the mangrove area [1, 2]. Central Java (province) is one of the area which has many long coastline, especially in the North Coast (Pantura), as stated by Suwartinah et al [3]. Most of the coastline in pantura is occupied by mangrove stands and associate with muddy substrate, even though it has also a
little of sandy beach. The most important cultivated commodities here were milkfish, shrimp, seaweed, both as monoculture or polyculture. Most fishes culture uses semi-intensive practice which provided fabrication feed (pellet).

In the mean-time, along the coastal waters there is an intertidal action which cause the hydro-oceanography vary dynamically [2]. Tidal action is very useful in term of water circulation because there will be water replacement (washing) naturally [1]. However, tides are also carry material and energy; including contaminants from outside and to be accumulated on the floor of mangrove stands or the other substrate. Cultivation activity itself also provides feed that triggers the vulnerability of waste/ pollution of unconsumed feed and feces that disturb the environmental balance. This is subject to be managed, especially to reduce the contaminant by using vegetative agent through soft rehabilitation, such as with seaweed. The soft rehabilitation actions are highly dependent on existing environmental conditions, i.e. physical, biological and chemical factors. Therefore it is very important to identify the condition of pond waters, especially through saprobic analysis using planktonic diversity.

The purpose of this study was to identify the quality of the northern coastal waters of Central Java (pantura), especially in areas that apply a wide aquaculture practice. Besides, it is also to analyze the potential of cultivant enrichment with sea weeds. The expected results are recommended to manage and preserve of water quality. It was also to encourages the addition commodities of aquaculture that are not only profitable economically, but also ecologically functional through increasing the stability of energy circulation.

2. Methodology

The study was conducted in coastal waters of Central Java during dry season 2016 mainly to the locations widely practicing pond cultivation; namely Brebes, Pemalang, Semarang, Demak, Pati and Jepara. Plankton were taken by sampling at least at 3 different sites as repetition, included different pond, public irrigation and coast line waters. The water sample was taken as much as 30 liters and filtered using plankton net no 25 as done by Hidayat et al [8]. The physico-chemical parameters were also measured including temperature, turbidity, water clarity, salinity, nitrate content and pH. The identification of plankton was performed under binocular microscope by using Sedgewick Rafter Cell (SRC) Counter, as done by Suprobowati et al [10] and Madusari et al [11]. Plankton counting and identification were done to find the species composition and individual number. The samples from one station were then accumulated on single sample to represent a location. Plankton and physico-chemical analysis were done in the Laboratory of Ecology and Biosystematics, FSM Diponegoro University. Data was also taken from secondary references by modifying the original data.

The plankton data were then analyzed through descriptive and semi-quantitative ways, including Biodiversity Shannon-Wiener Index (H'), evenness index (e) and Saprobic Index [4]. Saprobic index was implemented to analysis the quality of the waters, as done by Basmi [5]. The detailed analysis of the indices was as follows:

**Diversity Index (H'):** Species diversity index was used to identify the stability of the ecosystem by using Shannon-Wiener index (H'). The formula was as follow:

$$H' = - \sum \left( \frac{n_i}{N} \right) \ln \left( \frac{n_i}{N} \right)$$

In which, 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:

$$e = \frac{H'}{\ln S}$$

Where: e = evenness Index; H' = diversity index of Shannon-Wiener; and S = number of species
Saprobic Index: Dresscher and Mark method was adopted to determine saprobic index as done by Basmi [5], calculated by the 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 (Polisaprobik)
B = Number of species groups Euglenophyta (α-Mesosaprobik)
C = Number of species groups Chloroophyta (β-Mesosaprobik)
D = Number of species groups Chrysophyta (Oligosaprobik)

3. Results and Discussions
The diversity of the plankton in Central Java coasts were varied generally between 10 – 28 even though in Jepara was higher reached 42 species. The above species number was consistent to Nugroho et al [6, 7] which found the value between 10 – 26 species. The smallest number of species were found in Pati and Pemalang. During rainy season, most water in Pati; like other ponds in Pantura, is used for conventional pond. However, however during dry season the farmer transformed it into salt pond. This dynamic will affect significantly to the natural cycle of lives therein, mainly plankton [1]. A different species number were found in Jepara water, amounted 42 species as reported by Purwanti [9]. It is likely that this location was different in hydro-oceanography natures. Coastal line in Jepara was dominated by sandy beaches [9] and least in muddy substrate as the other Pantura waters. Therefore, Jepara has a richer oceanic plankton. The abundant and diversity of the plankton of central Java waters (Pantura) were mentioned in Table 1.

The most widely found species in panture were Oscillatoria sp, Rhizosolenia styliformes, Surirella sp and Lyngbia conferoides. This finding is consistent to Madusari et al [11] which found many Oscillatoria in Brebes and Purwanti [8] in Jepara coastal waters. These species are prefer to live in high nutritious waters [12]. Measurement of nitrate concentrations in Brebes were between 10 - 15 mg/lt. Rizhosolenia was also the dominant species and widely found in Belitung as found by Widjaningsih et al [13]. This species was similar to the above location and was affected by the presence of high nitrate concentration [12].

Tabel 1. The abundant and diversity of the phytoplankton of central Java (Pantura) waters

| No | Plankton | Number of individual / liter |
|----|----------|-----------------------------|
| 1  | Actinocyclus sp | 656 |
| 2  | Asterionella sp | 45 55 |
| 3  | Bacillaria paradosa | 7 65 |
| 4  | Bacteriasterum delicatulum | 118 |
| 5  | Bacteriasterum hyalinum | 302 |
| 6  | Bacteriasterum varians | 367 |
| 7  | Bacteriasterum sp | 1141 |
| 8  | Cerataulina bergonii | 65 |
| 9  | Chaetoceros affinis | 564 |
| 10 | Chaetoceros costatus | 4 997 |
| 11 | Chaetoceros compressus | 2542 |
| 12 | Chaetoceros didymus | 669 |
| 13 | Chaetoceros spp | 1509 |
| 14 | Cosinodiscus asteromphalis | 10 131 |
| 15 | Ceretron spp | 1220 |
| 16 | Cyclotella meneghiniana | 4 919 |
| 17 | Cyclotella operculata | 66 |
|   | Species                  |   |   |   |
|---|-------------------------|---|---|---|
|18 | Diatoma spp             |10 |   |   |
|19 | Encyonema sp            |17 |   |   |
|21 | Encyonema sp            |17 |   |   |
|22 | Fragillaria sp          |   |124|   |
|23 | Gymnosphaera            |7  |   |   |
|24 | Grammatophora sp        |   |171|   |
|25 | Guinardia delicaulata   |   |141|   |
|26 | Gyrosigma atenuatum     |85 |17 |   |
|27 | Hemiaulus hauckii       |58 |   |   |
|28 | Hemiaulus hauckii       |58 |   |   |
|29 | Lauderia annulata       |79 |   |   |
|30 | Melosira sp             |164|75 |4  |
|31 | Navicula sp             |41 |17 |70 |
|32 | Nitzchia sp             |116|   |32 |
|33 | Phaeodactylum sp        |   |22 |   |
|34 | Pseudonitzchia serrata  |7  |   |66 |
|35 | Rhizosolenia stylicharmis|97 |119|27 |
|36 | Rhizosolenia alata      |   |   |275|
|37 | Robdonella lomanius     |48 |   |   |
|38 | Skeletonema costatum    |3  |   |184|
|39 | Surirella sp            |170|68 |27 |
|40 | Synedra ulna            |57 |92 |112|74 |
|41 | Tabellaria flocculata   |6  |   |289|
|42 | Thalassiosira spp       |   |   |184|
|43 | Thalassiosira spp       |   |   |184|
|44 | Thalassiosira nitcheiodes|198|
|   | **Chlorophyceae**        |   |   |   |
|45 | Cladophora sp           |74 |   |20 |
|46 | Closterium sp           |34 |3  |4  |
|47 | Coelastrum sp           |   |   |275|
|48 | Chlorella sp            |6  |61 |249|
|49 | Gonatozygon sp          |   |   |105|
|50 | Neutrium digitus        |92 |   |   |
|51 | Microspora wileana      |7  |   |   |
|52 | Stigeocyclus puscheri    |11 |   |   |
|53 | Tetraedron sp           |   |   |23 |
|54 | Volvox sp               |   |   |159|
|   | **Cyanophyceae**        |   |   |   |
|55 | Anabaena sp             |92 |24 |   |
|56 | Ankistrodesmus          |10 |   |   |
|57 | Anapitheca stagnina     |10 |   |   |
|58 | Calotrix sp             |   |   |486|
|59 | Gloeotrichia echinulata |78 |   |53 |
|60 | Nodularia hawaiiensis   |7  |   |   |
|61 | Trichodesmium erythraeum|   |   |48 |
|62 | Trichodesmium sp        |   |   |44 |
|63 | Lyngbia confervoides    |119|187|27 |
|64 | Oscillatoria formosa    |57 |68 |489|
|65 | Polycystis sp           |71 |   |   |
|   | **Dinophyceae**         |   |   |   |
|66 | Ceratium fusus          |14 |24 |79 |
|67 | Ceratium hirundinella   |28 |   |236|
|68 | Dinophysis norvegica    |57 |11 |34 |
|69 | Dinophysis spp          |108|7  |79 |
|70 | Gonyaulax sp            |   |   |66 |
|71 | Peridinium sp           |   |   |787|
|72 | Noctiluca scintillans   |   |   |131|
|73 | Pyrocystis nocticula    |181|27 |   |
|74 | Protoperidium sp        |   |   |10 |
Prorocentrum micans 37
Prorocentrum sp 8

| Jumlah total individu (N) | 1078 | 691 | 1219 | 1258 | 358 | 15733 |
|---------------------------|------|-----|------|------|-----|-------|
| Jumlah jenis              | 12   | 10  | 25   | 28   | 10  | 42    |

*) Purwanti, 2011

The diversity index (H') varies from 1.83 to 2.9; higher than the observations done by Nugroho et al [6] in Semarang waters (only 1.52) or Afiati et al [7] with a value as low as 1.68. However, in PLTU of Central Java [14] reported a closer range between 1.7 - 1.9 (average 1.75). The magnitude of these values indicated the stability condition of coastal ecosystems in small to medium category [4], so that it is suffer to environmental disturbances. Many community interactions take place in the aquatic area in the form of cultivation activities, such as water management, feeding, competitor control and harvesting.

**Figure 1. Biodiversity (H') and evenness (e) indices of phytoplankton in north coast of Central Java**

Ponds in Batangan (Pati) especially, and some part of Wedung ponds; the ponds were also functioned as a salt pond. Salinity conditions in Wedung waters range from very low 15 ppt and can reach to 49 ppt [15]. Such salty conditions were greatly affect the quality of aquatic lives, including plankton [5]. In irrigation of the public waters, the stability was affected by many activities and therefore disturbances, especially the existence of tidal activity, boat activities, pollution and fishing. Nutrient content, especially nitrate within water was high, more than 10 mg / lt (over than standard water quality). This will trigger eutrophication (high fertility) that disturb the environmental balance. The smallest stability of the ecosystem was found in the water of Pemalang, which was associated with their traditional practice. This practice, mostly least in feed supply and therefore provoke intensive grazing to plankton by fishes. In Brebes, most of the pond applied polyculture, including milk fish or shrimp combined with seagrass of *Gracillarian verrucosa* or *G gigas*. These seagrass can grow very fast and strongly absorb the nutrients of the water [16]. The existence of seagrass and associate thallus, directly or indirectly, provided fulfillment of foods for fishes and reduced the plankton grazing.

In term of saprobic index, showed that the values were between positive 0.33 to 2.27. This value indicates the status of contaminations were very little up to lightly contaminated. The heaviest contamination was found in ponds in Batangan Pati at 0.33 saprofic index with small contaminated value, related to salt factor as discussed before. The slightly high contaminants were counted in Pemalang and Demak, with index values of positive 1.57 and 1.63, respectively. The low contamination conditions in Pemalang (the largest saprofic index: 1.57) were attributed to the practice of traditional and monoculture (as previously noted) manners. In Wedung, the main reason to low value was relatively less intensive in terms of feeding to the milkfish cultivation [15]. As a result the potential wastes (feed and feces) were also not too many. The high value of nitrate is believed came
from public waters [15]. In Brebes waters, the practice of polyculture with grass is widely done, but there was also poultry farming activities around there [11] which is likely also to contribute to higher pollutant value. The nitrate value in Brebes ranged from 10 to 15 mg/liter higher than in Pemalang. Value of environmental factors are shown in Table 2.

Table 2. Saprobic status of the waters of north coast of Central Java

| No | Station         | Saprobic Index | Pollutant category          | Water status        | Pollutan materials                                      |
|----|-----------------|----------------|------------------------------|---------------------|--------------------------------------------------------|
| 1  | Randusanga, Brebes | 1.40           | B-mesosaprobik/oligosaprobik| Lightly polluted    | Small amount of organic and anorganic sources          |
| 2  | Ulujami, Pemalang | 1.57           | Oligo/β-mesosaprobic        | very small polluted | Small amount of organic and anorganic sources          |
| 3  | Tapak, Semarang  | 1.34           | B-meso/oligosaprobik        | Lightly polluted    | Small amount of organic and anorganic sources          |
| 4  | Wedung, Demak   | 1.63           | Oligo/β-mesosaprobic        | very small polluted | Small amount of organic and anorganic sources          |
| 5  | Batangan Pati   | 0.33           | β/α-mesosaprobic            | Lightly polluted    | Small amount of organic and anorganic sources          |
| 6  | Jepara          | 2.27           | oligosaprobic               | very small polluted | Small amount of organic and anorganic sources          |

Based on the condition of small water contamination in the waters of Central Java, especially their H⁺ and Saprobic Indices, it is possible to enrich with additional cultivant; approaching to integrated cultivation of IMTA (Integrated Multitrophic Aquaculture), at least as done in Brebes. Enrichment of cultivation using seaweed has not been done at Demak and Semarang, where it is associated with turbidity and depth conditions (limited penetration of sunlight); so it tends to be less appropriate. In Pati, this was not practiced yet similar to Demak and Semarang, but the chemical factor, i.e. salt concentration, become limited factor here. However, it can still be implemented, especially for ecological and economic purposes. In such a case, it required an innovation to plant in such a way that seaweed can grow and functional to control of turbidity. If turbidity can be suppressed, then the penetration of sunlight also deeper, and seaweed become suitable. The best pond conditions for seaweed cultivation enrichment was found in Jepara (highest in saprobic index i.e. 2,22), associated with high sandy and transparent substrate conditions (low turbidity between 17.9 - 20.4 NTU). Environment factors in coastal areas of Central Java as mentioned in Table 3.

Table 3. Environment factors in northern coastal areas of Central Java

| No | Stations         | pH   | DO (mg/lt) | Salinity (ppt) | Nitrate (mg/lt) | Turbidity (NTU) | Temperature (°C) |
|----|------------------|------|------------|----------------|-----------------|-----------------|------------------|
| 1  | Randusanga, Brebes | 5.5 - 6.5 | 4.0 - 5.4 | 24 - 30        | 10 - 15         | 45.7 - 78.5     | 28 - 32          |
| 2  | Ulujami, Pemalang | 5.0 - 6.3 | 5.3 - 6.1 | 27 - 30        | 0.75 - 1        | -               | 29 - 33          |
| 3  | Tapak, Semarang  | 7.4 – 7.7 | 5.9 - 6.0 | 16 - 18        | 5.3 - 5.5       | 313 - 317       | 32.7 – 33.2      |
| 4  | Wedung, Demak   | 4.4 - 6.5 | 5.3 - 7.9 | 15 - 49        | 8.32 - 20.4     | 105 - 196       | 26 - 30          |
| 5  | Batangan, Pati  | 5.48 - 5.78 | 6.37 - 9.46 | 16.8 - 33.1 | 11.63 - 13.39 | 72 - 196       | 30.4 - 31.8      |
| 6  | Jepara          | 7.2 - 8  | 5.1 – 5.4 | 19 - 24        | -              | 17.9 - 20.4     | 28 - 31          |
| 7  | Standart        | 6 - 9  | >4         | 15 - 30        | < 10           | 2 - 30         | Deviasi 3        |

**) Suwartinah et al, 2011

4. Conclusions
The stability condition of north coastal ecosystem in Central Java were in small to medium categories with the diversity index varies from 1.83 to 2.9. The species composition varied between 10 to 42 species. The most widely found species were *Oscillatoria* sp, *Rhizosolenia styliformes*, *Surirella* sp and *Lyngbia conferoides*.

Saprobic index indicated the status of contamination was still very little up to lightly contaminated (positive 0.33 to 2.27). The condition of small contamination in these waters of Central Java, especially in accordance to the H’ index, showed possibility to enrich with additional cultivant; approaching to integrated cultivation of IMTA (Integrated Multitrophic Aquaculture), at least as practiced in Brebes.

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