# The Effect of Compost Application in the Silvofishery Pond with Different Mangrove Species on the Phytoplankton Community

*by* Endah Dwi Hastuti

**PAPER · OPEN ACCESS**

# The Effect of Compost Application in the Silvofishery Pond with Different Mangrove Species on the Phytoplankton Community

# The Effect of Compost Application in the Silvofishery Pond with Different Mangrove Species on the Phytoplankton Community

**E D Hastuti[1]\*, R B Hastuti[1], and R Hariyati[1]**

[1] Department of Biology, Faculty of Science and Mathematics, Diponegoro University
Jl. Prof. Soedarto, SH Tembalang, Semarang 50275, Central Java, Indonesia
\*E-mail: endah_pdil@yahoo.com

## 1. Introduction

The effort to revive aquaculture activity in the damaged coastal area has been conducted through some methods, including the replacement of farmed species [1] and the conservative farming method [2]. Silvofishery is the most applied method in the environment-friendly aquaculture activity which had been developed and applied in many regions in Indonesia [3,4]. Unfortunately, the application of silvofishery is not enough to optimize the pond's water quality [5]. Thus, further, improvement is required to achieve appropriate water quality in the silvofishery pond for fish culture.

Coastal brackishwater pond nowadays faces a serious problem regarding water quality issues. Instead of the degraded ecosystem, increasing pollutant supply has been a serious concern in the aquaculture activity [6,7]. Improved industrial activities and expanded settlements altered the effluent discharge from the upland area [6,8]. The effluent which generally contains pollutants is accumulated in the estuarine and dispersed in the coastal area [9]. Thus, the potential of brackish water pond to get contaminated is quite high since estuarine is its main water source.

Improvements of water quality have been conducted in fish culture activity [10], whether it is traditional, semi-intensive or intensive pond system. Various technique, tools, chemicals [11] and biological [12,13] products are developed to improve water quality [14,15]. Application of fertilizer

i.e., manure is one of the known methods to improve pond's water quality, especially to improve plankton productivity [16,17].

As the increased application of silvofishery in aquaculture, a problem related to the growth of mangrove plants arises. Increased complexity of mangrove's density, canopy and roots cause a decrease in environmental quality and promote pest occurrence. Mangrove canopy creates shading on the pond's water body, decreasing light penetration and further decrease on primary productivity by phytoplankton [17,18]. Moreover, dense mangrove canopy provides settlements for some pests, such as lizard and crane [19,20]. Maintenance of mangrove litter is conducted through the pruning of mangrove branches [21]. Thus, the light penetration could be improved, and the potential of mangrove plants to get utilized by pests as settlement of hiding place could be minimized.

Recent studies showed that mangrove litter has the potential to be utilized as the source of compost [17]. Just like any other plant species, mangrove litters (especially leaf) contain the various nutrient compound. The litter production of mangrove plants is generally rapid [22,23]. Mangrove plants are known to produce leaf litter dry weight as much as 7 - 10 tons/ha/yr [23]. Unfortunately, the natural decomposition process of mangrove litter requires a long period, especially when it has been accumulated. It requires at least 78 to 96 days for *A. marina* litter and 151 to 476 days for *R. mucronata* litter to reduce its dry weight to half of its initial weight [24]. In the pond ecosystem, this may invite the unexpected pest, i.e. crabs [25]. Thus, management of mangrove plants in the silvofishery pond is required to keep the pond in its optimum state.

Compost is an organic material produced from the decomposition process of organic wastes, such as litters, leftovers, dungs, etc. [26,27]. Compost has been utilized for various purposes, such as growing media [28], fertilizer [29], and has been tested to improve water quality in the freshwater pond [30]. However, the application in brackishwater aquaculture is barely known.

Phytoplankton is an aquatic organism which is sensitive to several environmental factors, such as the light and nutrient [31,32]. It also has a short lifespan. Thus, the fluctuation of phytoplankton occurs rapidly [33]. Ecologically, the sensitivity of phytoplankton is useful to indicate the change of environmental condition.

Phytoplankton also plays an important role in the aquatic ecosystem as the primary producer [34]. Phytoplankton utilizes dissolved nutrient to grow. Thus, nutrient enrichment could potentially improve the growth of phytoplankton[35] in the silvofishery pond. Moreover, its role as a primary producer may support the growth of another organism such as zooplankton or even the cultivation itself through some food chains [36].

Considering the importance of phytoplankton in the pond ecosystem and the application of compost to improve the water quality, this research aimed to study the distribution of phytoplankton community in the silvofishery pond and to analyze the impact of compost application in the silvofishery pond planted with different mangrove species.

## 2. Experimental Design

The experiment was located in the Mangunharjo Village, Tugu District, Semarang City, while the research was conducted in September 2017. The experiment was conducted by adding 2 kg of compost to a 5 x 5 m2 fishpond. Three different pond settings were utilized in the experiment along with one control pond without the addition of compost. The experimental fishponds were planted with different mangrove species, including *Avicennia marina*, *Rhizophora mucronata* and the mix of both. The compost was spread two weeks before the sampling activity of phytoplankton was conducted. The sampling of phytoplankton was conducted by filtering 100 liters of pond water into 100 ml bottle using a plankton net. Identification of plankton's composition and abundance was conducted in the Laboratory of Ecology and Biosystematics, Faculty of Science and Mathematics Diponegoro University. Identification of plankton was based on the book by Shirota [37].

Data analysis was conducted for descriptive and statistic. Statistical analysis was conducted by chi-square while descriptive analysis was conducted for similarity index and Shannon's diversity and evenness indices with the following formula:
*Similarity index*

$$J' = A / (B + C - A) \tag{1}$$

Notation:
  J' = similarity index
  A = number of phytoplankton species found in pond x and pond y
  B = number of phytoplankton species found in pond x
  C = number of phytoplankton species found in pond y

*Diversity and evenness index*

$$H' = -pi \ln(pi) \tag{2}$$

$$E = H' / \ln(S) \tag{3}$$

Notation:
  H' = diversity index
  E = evenness index
  S = number of species
  $pi$ = $n_i / N$
  $n_i$ = abundance of plankton species –i
  N = total abundance of plankton

## 3. Results

Twelve phytoplankton species were identified in the silvofishery pond's water sample. However, the number of plankton species existed in the treatment was ranging from 5 to 7 species. Detailed identification result along with the diversity and evenness indices of phytoplankton in the silvofishery pond during the research is presented in Table 1.

**Table 1.** Composition, diversity and evenness indices of phytoplankton in the silvofishery pond (indv.l$^{-1}$)

| No. | Plankton Species | Avicennia | Rhizophora | Mixed | Control |
|-----|------------------|-----------|------------|-------|---------|
| A. | **CHRYSOPHYTA** | | | | |
| 1. | Closterium sp | 35 | | | |
| 2. | Melosira sp | | | | 17 |
| 3. | Merismopedia sp | | 17 | 17 | 17 |
| 4. | Microspora sp | | 17 | 17 | |
| 5. | Maugeotia sp | 17 | 17 | | |
| 6. | Navicula sp | 17 | | | |
| 7. | Nitzschia sp | 35 | 17 | 35 | 17 |
| 8. | Oscilatoria sp | 17 | 17 | | 17 |
| 9. | Surirella sp | 17 | | | |
| 10. | Synedra sp | 17 | 17 | 17 | 17 |
| B. | **CHLOROPHYTA** | | | | |
| 11. | Chlorella sp | | | 17 | |
| C. | **CYANOPHYTA** | | | | |
| 12. | Microcystis sp | | 17 | | |
| | *Number of Species* | *7* | *7* | *5* | *5* |
| | *Total Abundance* | *155* | *119* | *103* | *85* |
| | *H'* | *1.88* | *1.95* | *1.56* | *1.61* |
| | *E* | *0.97* | *1.00* | *0.97* | *1.00* |

Table 1 shows that silvofishery pond planted with *A. marina* and *R. mucronata* had the higher diversity of phytoplankton species than the mixed and control ponds. The result shows that the control pond had the lowest abundance compared to the ponds with compost addition. Instead of having more

number of species, silvofishery pond with *A. marina* and *R. mucronata* plants had higher diversity indices. This result indicates that there was a slight improvement of phytoplankton community due to compost application in terms of its number of species and abundance.

Analysis of the phytoplankton composition between treatments showed that the similarity was ranging from low to medium. Statistical analysis by chi-square showed there were significant differences of phytoplankton composition of the treatments. Table 2 shows detailed analysis result for similarity index and chi-square.

**Table 2**. Similarity index and chi-square analysis result of phytoplankton communities in the compost added silvofishery ponds

|              | A. marina | R. mucronata | Mixed | Control |
|--------------|-----------|--------------|-------|---------|
| **A. marina**    | ---       | 40%          | 20%   | 33.3%   |
| **R. mucronata** | 123.6**   | ---          | 50%   | 50%     |
| **Mixed**        | 149.6**   | 73.5**       | ---   | 42.9%   |
| **Control**      | 115.7**   | 64.1**       | 73.2**| ---     |

Notation: **significant at $\alpha = 0.01$

Table 2 shows that the treatment pond planted with *R. mucronata* generally has a strong relationship with another treatment. Inversely, the pond planted with *A. marina* tends to have a weak relationship with another treatment. This indicates that the environmental quality of silvofishery pond planted with *R. mucronata* along with the addition of compost was in between of the ponds with *A. marina*, mixed mangrove, and control.

Chi-square analysis showed that the likelihood of phytoplankton composition among treatments was low. Thus, the difference of phytoplankton composition between treatments was significant. This indicates that each mangrove species provides different support on the phytoplankton's community.

## 4. Discussion

The result showed that the number of phytoplankton species as well as its abundance was poor. This could be caused by the limitation of water circulation [38]. Generally, brackishwater pond is an isolated ecosystem in which water supply and discharge only occur through a single gate. This system was also applied in most of the ponds, both silvofishery and traditional in the coastal area of Semarang City. Moreover, on the silvofihsery pond which generally applies a traditional system, the circulation of water is dependent on the tidal activities [39]. Thus, the exchange of water along with the nutrient and microorganism from the open water only occurs in a limited time and rate.

The limitation on the exchange of microorganism, including phytoplankton causes the restriction to the enhancement of species diversity [40]. The adaptation ability of plankton species is required to survive in the pond ecosystem. At tide period, opened canal supplies the nutrient and oxygen to the to the closed water environment [41] such as in pond ecosystem. However, during the ebb period the competition on nutrient increases since the water stays still. The condition was proven in this research in which the maximum number of plankton variation was 7 species.

The difference of plankton composition of the treatment ponds showed that particular mangrove species provides a different impact on the water quality. Addition of compost increased the population of phytoplankton. However, the species composition of phytoplankton is determined by the mangrove species. The condition of mangrove, both composition and density have a significant effect on the population of plankton and benthos [42].

The analysis result showed that the phytoplankton community between treatment was different significantly. It is proven by the low similarity indices and as well as the significance of the chi-square analysis. The result of this research indicated that fertilizer from one mangrove species supported the variation and abundance of plankton species. Thus, mixing litters from several mangrove species is not recommended in the production of compost.

Each plant species excrete different chemical compound to the environment to attract or distract animals for its survival purposes [43,44]. On the terrestrial plants, the impact is obvious and monitorable from its associated animals. Unfortunately, for mangrove plants especially those planted in the pond, the animal community is less monitorable. Generally, mangrove plants are surrounded by various organisms on its floor, especially from the crustacea and mollusk [45]. However, since mangrove plants are inundated by water, the habitat for the associated community is not well developed.

The nutrient composition provided by mangrove plants are different between species. The nutrient balance is affected by both the supply and uptake by the plant. Each mangrove species required a different proportion of nutrients which cause the difference in the availability of dissolved nutrient [46]. This affects the composition and abundance of phytoplankton in the silvofishery pond.

Compost has various advantages to improve soil quality and has been utilized in agriculture [47]. However, the advantage is not limited to agricultural activity, but also aquaculture [30]. Instead of providing nutrients for plants, compost also plays a role in stabilizing the soil nutrient and alkalinity [48]. Generally, compost contains C:N ratio between 15 to 25 [49]. Compost also has the characteristic of slow releasing nutrient [50]. Thus the uptake of the nutrient could be controlled. The application of inorganic fertilizer has shown the effect of soil acidification [51]. As the impact, the soil becomes poor of nutrient and could not be utilized for crops planting.

The application of compost on the aquaculture is mainly aimed to enrich the nutrient concentration in the pond and enhance the phytoplankton abundance [14]. However, more advantages could be obtained from the utilization of compost instead of inorganic fertilizer. Compost generally has small particles which could bind dissolved organic matters. Organic matters in the water consisted of fine sediment materials which also became the attaching place for pollutants, such as heavy metals [52]. When the fine sediment is bound to compost particles, it would be suspended on the pond's floor. Thus, excessive nutrient would be stored in the pond bottom.

Further advantages of the compost application include the enhancement of water clarity and decreasing dissolved pollutant concentration [17]. Increased light penetration into the water body increases the primary productivity of phytoplankton [14]. Unfortunately, the reduced dissolved nutrient concentration may decrease its support for phytoplankton. However, this could be useful in the pond ecosystem to avoid oversaturation of nutrient.

Naturally, mangrove plants actively produce litters during its growth. The litters of mangrove are a natural source of nutrient for coastal ecosystem [53]. However, the mangrove planting in the silvofishery pond is also expected to provide nutrient supply to the pond ecosystem which benefits aquaculture activity through the provision of natural food [54]. Unfortunately, mangrove litter requires a quite long time of degradation process [24]. Moreover, the nutrient availability in the pond could not be utilized optimally by phytoplankton due to the turbid water condition [55]. Thus, compost application is still needed, especially to improve physical water quality.

Compost application is a potential method to improve water quality and support the growth of phytoplankton at the same time [56,57]. Another utilization of compost-related with aquaculture is for algae culture [14]. However, the potential is limited due to the dynamic of pond water. The effect of compost application cannot be maintained for a long period. Supply of water during tide current carries new organic matters to the pond ecosystem which increase its turbidity, nutrient, as well as pollutant content [58]. Thus, the impact of compost application is reduced, and the water condition is reverted to its previous condition.

To provide the optimum effect, compost application should be conducted periodically. Further observation is required to analyze the best frequency of compost added to the pond. However, the reduction rate of compost effect might be varied according to its tidal activity. The frequency and level of tide determine the exchange rate of pond water.

Improved water quality in the silvofishery pond due to compost application supposed to provide better support for fish growth. Moreover, the community the enrichment of phytoplankton community and population improve the food chain both the quality and quantity. However, the application of compost in aquaculture requires appropriate management especially regarding its frequency and volume as well as the impact on the growth of the fish.

## 5. Conclusion

Twelve phytoplankton species were found in the silvofishery pond, but only 5 to 7 species were found in each treatment in which Nitzchia sp. and Synedra sp. were the only species found in all treatments. The abundance of phytoplankton in the compost added treatments were slightly higher than in the control treatment. There were significant differences in the composition of phytoplankton in the pond. However, the difference was caused by mangrove species variation rather than the application of compost.

## Acknowledgment

## References

# The Effect of Compost Application in the Silvofishery Pond with Different Mangrove Species on the Phytoplankton Community

| Exclude quotes | Off | Exclude matches | Off |
|---|---|---|---|
| Exclude bibliography | Off | | |

# The Effect of Compost Application in the Silvofishery Pond with Different Mangrove Species on the Phytoplankton Community