Evaluation on The Change of Water Quality and Survival Rate of Mangrove Seedling within Silvicultural Pond at Semarang City during Early Dry Season

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Introduction

Mangrove plantation require suitable sites to support its survival and growth. According to [1], soil suitability plays important rules in determining mangrove survival and growth. Suitable plantation site for mangrove should have silty or clayey soil, slopy topography and covered by tidal. Eventhough mangrove habitat is originally in the tidal area, but some aquaculture activities had applied mangrove plantation within ponds named silviculture. Integration of mangrove in ponds was purposed to rehabilitate coastal area without interfering aquaculture activities as well as to support the sustainability for aqculture.

The application of silvofishery farming system was purposed to control the pond sewage as well as to provide natural food web for the cultivated biota. According to [2], mangrove plays important role in purifying pond water approximately up to 70 – 75% of nutrients and provide natural food for up to 42 species of matrobenthic organisms. The water circulated system involving mangrove plants had been proved to enhance the pond productivity up to 30%. Hence, mangrove plantation in silvofishery pond is an important activity as a rehabilitation effort of mangrove ecosystem.

The application of mangrove plantation in aquaculture pond should face limitations. Different soil condition as well as its oceanographic activities became major consideration for mangrove survival and growth. Sediment burial could cause mortality of mangrove seedling as mentioned by [3] which showed that sediment burial beyond 7 cm increased the mortality of mangrove seedlings. Inversely, the exposure of mangrove seedling could contribute a better stem elongation. In such case as siviculture, mangrove seedling should have better height growth but vulnerable to sediment burial. According to [4], Avicennia is vulnerable to sediment

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burial, while Rhizophora is tolerant to sedimentation.

Mangrove seedling survival and growth is driven by salinity, tidal action and availability of nutrients [5]. While according to [6], tidal inundation should be avoided in the establishment of mangrove seedling. Eventhough, tidal inundation define litter mixture as the source of nutrient for mangrove development. Mangrove survival and growth were better on the high intertidal area rather than low intertidal area [7].

Eventhough mangrove is tidal vegetation, salinity is major stress for mangrove development. A research conducted by [8] showed that salinity above 30 ‰ had significant effect on stomatal conductance and flourescence yield of mangrove leaves. Eventhough salt concentration is major stress for mangrove seedling establishment, but [9] noted that mangrove could survive to salinity of 90 ppt although its growth would not be optimal. Mangrove has a specific mechanism to remove or avoid salt stress from the environment.

Other factor affecting mangrove survival is ambient temperature. According to [10], increasing air temperature may lead to decrease of mangrove survival. Temperature effect the photosynthesis processes of mangrove leaves. Optimum mangrove temperature for photosynthesis is ranged from 28 – 32 °C, while leaf temperature of 38 – 40 ° C caused to cease of photosynthetic process of mangrove [11].

Main factor effecting the change of environment condition is global warming. Global warming had caused to increasing sea level rise which lead to higher tidal occurence and water inundation, increasing ambient temperature and increasing evaporation which lead to alter of salinity [12]. Another impact of global warming is the change of season and season length. Change of season and season length should alter the risk on the ecosystem survival and ecosystem balance [13]. Such change of season length in Indonesia had been noticed since last few years where dry season lasts longer than usual as well as significant increase on ambient temperature.

In order to achieve optimum mangrove rehabilitation, such information concerning the effect of plantation time on mangrove survival. Eventhough mangrove vegetations are prior to tropic area, but there is no appropriate information concerning the appropriate plantation time. In certain case such as silvofishery pond where mangrove plantation is limited to certain extent and environment condition, mangrove survival became an important factor to achieve its role in maintaining the carrying capacity for aquaculture activities. This research aimed to study the change of water quality and to evaluate the survival rate of mangrove seedling planted in early dry season.

Materials and Method

Research was conducted through field experiment involving silviculture pond in Mangunharjo, Tugu, Semarang. Mangrove seedling was planted inside the canals placed outside the pond canals including inlet canal and outlet canal. Inlet canal was purposed to refine the water quality and enhance primary productivity for the pond, while outlet canal was purposed to provide the effluent control from the pond. Total planted seedling for each mangrove species was 54 stands. Mangrove species involved in this research was Avicennia marina and Rhizophora mucronata including partial and combined plantation. This research was conducted for 4 moths from March to June 2015. Seedling plantation was conducted on late March, while observation of mangrove survival was conducted in early April (1st period) and early June (2nd period). Observations including water quality parameters such as temperature, turbidity, salinity, pH and DO. Survival rate of mangrove seedling was calculated for each mangrove species. Statistical analisis was conducted to analyze the significant difference of water quality parameters between observations using t-test method.

Result and Discussion

Data collection resulted there were variations of water quality between observations. Water quality parameters including temperature and turbidity decreased in 2nd observation, while salinity, pH and DO increased. Detailed observation result of water quality parameters achieved from 1st and 2nd observation is shown in Table 1.

Table 1. Water Quality Parameters Monitoring

No.	Parameter	Value	1st Observation	2nd Observation
1.	Temperature (°C)	Range	32.6 – 39.7	29.0 – 34.6
		Average ± Std.Dev	34.24 ± 1.31[a]	31.38 ± 1.22[b]
2.	Turbidity (NTU)	Range	92 – 933	80 – 842
		Average ± Std.Dev	379.74 ± 265.88[a]	313.01 ± 156.90[a]
3.	Salinity (‰)	Range	19.7 – 34.4	25.9 – 32.2
		Average ± Std.Dev	22.02 ± 1.12[a]	31.00 ± 0.85[b]
4.	pH	Range	4.7 – 11.04	8.11 – 9.79
		Average ± Std.Dev	7.49 ± 1.59[a]	9.26 ± 0.32[b]
5.	DO (mg/l)	Range	3.1 – 10.75	2.29 – 10.75
		Average ± Std.Dev	6.56 ± 1.62[a]	6.99 ± 1.95[a]

Annotation: different letter in the same row indicate significant difference; same letter in the same row indicate insignificant difference

Data collection showed that there were changes on water quality parameters. Water temperature showed significant difference between observations. Observation of water temperature in the 1st period showed the value of 34.24 ± 1.31 °C but in 2nd period decreased to 31.38 ± 1.22 °C. T-test analysis showed t value of 1.990 with probability level of 0.000 ($p < 0.05$). Turbidity also showed significant difference between observations. 1st observation showed the value of 379.74 ± 265.88 NTU while 2nd observation showed decreased value with 313.01 ± 156.90 NTU. Statistical analysis showed t value of 1.975 with probability level of 0.053 ($p > 0.05$). Water salinity increased from 1st observation to 2nd observation. Initial water salinity was 22.02 ± 1.12 ‰ while final salinity showed the value of 31.00 ± 0.85 ‰ which statistically showed significant difference with t value of 1.990 and probability level of 0.000 ($p < 0.05$). Water pH also showed significant difference including t value of 1.975 and probability level of 0.000 ($p < 0.05$). Initial pH value was 7.49 ± 1.59 while final pH was 9.26 ± 0.32 which showed significant increase. Observation of DO value showed average of 6.56 ± 1.62 mg/l on the 1st observation increasing in 2nd observation with average value of 6.99 ± 1.95 mg/l. The increasing DO value did not show significant difference between both observation period. Statistical analysis showed t value of 1.990 with probability of 0.187 ($p > 0.05$).

Analysis on the survival of mangrove seedling showed different rate for *Avicennia marina* and *Rhizophora mucronata*. Survival rate of *Avicennia marina* was lower than *Rhizophora mucronata*. Detailed information of mangrove seedling survival in silvofishery pond planted during early dry season is shown in Table 2.

Table 2. Mangrove Survival in Silviculture Pond During Early Dry Season Plantation

No.	Mangrove Species	Initial Abundance (stands)	Final Abundance (stands)	Mortality (stands)	Survival (%)
1.	*Avicennia marina*	54	9	45	16.67
2.	*Rhizophora mucronata*	54	17	37	31.48

Table 2 showed there was different level of survival rate between *Avicennia marina* and *Rhizophora mucronata*. Only 9 of 54 stands were observed in the final observation for *Avicennia marina*, indicating only 16.67% survival. While *Rhizophora mucronata* provide better survival performance with 31.48%, from 54 stands there were 17 stands survive. Hence, the mortality for *Avicennia marina* was higher than *Rhizophora mucronata*. Different level of survival showed there were different tollerance of mangrove seedling. Eventhough, low survival rate of mangrove seedling showed there was a prior stress from the environment to mangrove seedling during early dry season plantation.

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Season change is always followed by the change of ambient environment condition. In tropical countries, the environment change only occur in certain parameters. Ambient temperature in dry season usually lower than in rainy season [14]. Higher temperature in rainy season caused to the increasing evaporation of water which lead to alteration of humidity and rain production. This match the observation result where initial observation showed higher temperature while final observation which means in the middle of dry season was lower.

Decreasing turbidity value in 2nd observation was subjected to lower tidal activities. Low tidal activities decreased sediment mixture which further effect to lower sediment transport [15]. This low tidal activities also meant that there was lack of water supply from and to pond area. Hence, water exchange from coast and pond was avoided [16]. Lower tidal activities effect to calm water movement which provide chances for sedimentation of dissolved sediment. While this happen, lower turbidity would be achieved as shown in the observation result where 2nd observation had lower turbidity than the 1st observation.

Further effect of season change was water salinity. According to [17], water salinity is higher in dry season than in rainy season. Increasing salinity is caused by the decreasing freshwater supply from upstream. Hence, sea water would dominate the coastal area, especially in estuaries. Same condition occur in ponds. This is proved by the research result which showed significant increase of water salinity in the silvicultural pond during the research. Average salinity observed in 1st observation was 22.02 ± 1.12 ‰ increased to 31.00 ± 0.85 ‰ in 2nd observation.

According to [18], season change also effect to increasing water pH and DO. Both parameters was noticed to increase in this research. The increasing pH in dry season was caused by low supply of freshwater from the upstream which mostly contain decomposed materials. Furthermore, less concentration of decomposed materials in water should decrease oxygen utilization [19]. Increasing DO in dry season was also supported by better photosynthetic processes [20]. Low turbidity provide better light penetration into the water which suport phytoplankton photosynthetic activities.

Change of environment condition by season shifting was observed in this research. Changes on environment parameters could effect the survival and growth of mangrove seedling. The result of this research showed low mangrove seedling survival was prior to increasing salinity stress. According to the research result, water temperature decreased to tolerated value for mangrove growth, while turbidity decreased though insignificant, while pH and DO increased to better value. Only salinity had exceeded optimum limit. According to [8], salinity above 30 ‰ effect to significant decrease of stomatal conductance and flourescence yield of mangove leaves which mean that photosynthetic processes would be limited. While observation result showed salinity level of 31.00 ± 0.85 ‰. Temperature was still in the optimum range for photosynthesis which is ranged from 28 – 32 °C while the observation result showed the value of 31.38 ± 1.22 °C.

Conclusion

Early dry season showed significant change on the environment parameters for water quality for temperature, salinity and pH. The change of water quality parameters were still in the optimum range for mangrove growth including temperature decrease from 34.24 ± 1.31 °C to 31.38 ± 1.22 °C; turbidity decreased from 379.74 ± 265.88 NTU to 313.01 ± 156.90 NTU; pH increased from 7.49 ± 1.59 to 9.26 ± 0.32; and DO increased from 6.56 ± 1.62 mg/l to 6.99 ± 1.95 mg/l. Only salinity increase had value exceeded the optimum range which threaten mangrove survival, from 22.02 ± 1.12 ‰ to 31.00 ± 0.85 ‰. Seedling survival showed low value for both mangrove species, including 16.67% for *Avicennia marina* and 31.48% for *Rhizophora mucronata*. Hence, early dry season is not suitable for mangrove plantation since season shifting would threaten mangrove survival for *Avicennia marina* nor *Rhizophora mucronata*.

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