Effect of Silvofishery on Ponds Nutrient Levels

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Abstrak

Pengaruh Silvofishery Terhadap Kandungan Nutrien di Tambak

Taman Nasional Sembilang merupakan salah satu taman nasional yang terletak di Sumatera Selatan dan menjadi kawasan mangrove terbesar di barat Indonesia. Sebagian besar wilayah mangrovenya telah mengalami alih fungsi menjadi tambak pasang surut. Hal ini menyebabkan timbulnya kekhawatiran kerusakan mangrove di taman nasional. Salah satu upaya untuk mempertahankan wilayah mangrove adalah dengan melakukan sistem silvofishery, yaitu penanaman mangrove dan budidaya bandeng dilakukan secara bersamaan di tambak. Penelitian ini bertujuan untuk menganalisis kualitas air dan kondisi nutrien di tambak di daerah restorasi silvofishery di Taman Nasional Sembilang. Penelitian dilakukan dengan metode purposive sampling di tambak silvofishery, tambak non-silvofishery, dan badan air sungai di seluruh wilayah taman nasional. Pengukuran dilakukan terhadap parameter kualitas air dan kandungan nutrien khususnya nitrat dan fosfat. Hasil penelitian menunjukkan bahwa kehadiran tanaman mangrove di daerah tambak mampu memperbaiki kandungan oksigen dan pH air tambak. Mangrove juga menunjukkan kemampuan dalam mengikat nitrat yang secara tidak langsung akan mencegah air tambak dari polusi. Namun, kandungan fosfat tinggi menunjukkan bahwa tanaman mangrove muda di wilayah restorasi belum mampu mengikat nutrien ini secara signifikan. Hasil penelitian ini menunjukkan bahwa hutan mangrove sangat bermanfaat bagi kegiatan budidaya tambak karena kemampuannya dalam menyerap polutan nutrient.

***Kata kunci**: silvofishery; kolam; nitrat; fosfat; Taman Nasional Sembilang*

Abstract

Sembilang National Park is one of the national parks which is located in South Sumatera and became the largest mangrove area in western Indonesia. Most of the mangroves area in this national park has been experiencing conversion to be tidal ponds. This has resulted in concerns on mangrove forest destruction in the park. One of the efforts to maintain mangroves area is by applying silvofishery system, which is mangrove planting and cultivation of milkfish in ponds performed simultaneously. This study aims to investigate the water quality and nutrient condition in the ponds in the area of silvofishery restoration at Sembilang National Park. The study was conducted by purposive sampling method in the silvofishery ponds, non-silvofishery ponds, and river water bodies throughout the park. Measurements conducted on water quality parameters and nutrient content, especially nitrate and phosphate. The results showed that the presence of mangrove in the ponds area is able to improve the oxygen content and pH of pond water. Mangroves also demonstrated the ability to bind nitrates which indirectly will prevent the pond water from pollution. However, the high phosphorus content showed that young mangrove plants in the restoration area have not been able to significantly bind the of this nutrient. The results of this study showed that mangrove forests are very beneficial for aquaculture activities because of its ability to absorb nutrient pollutants.

***Keywords**: silvofishery; ponds; nitrate; phosphate; Sembilang National Park*

Introduction

Sembilang National Park is located in Banyuasin regency, South Sumatra and is the largest mangrove area located in the western part of Indonesia (Suwignyo *et al*., 2005). Mangrove areas in this Sembilang officially became a national park on the recommendation of the Governor of South Sumatra (Letters of Recommendation No. 522/5459/BAPPEDA-IV/1998), and the ministerial

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decree on March 15, 2001, No.76/Kpts-II/2001 on Appointment of Forest Area in South Sumatra Province, which also included the designation of the area as a National Park Sembilang. This was then followed up by the Governor of Sumatra (based on no 522/5128/I letter dated October 23, 2001), by requesting the establishment of Sembilang National Park area with an area of 205750 ha. Determination Sembilang mangrove area in a national park does not mean the problem of mangrove conservation in this region is complete. Determination of the region into a new national park was in 2001, although since the 1990s the surrounding community has many uses in the mangrove areas as land Sembilang breadwinner. Many mangrove areas have become the pond area. As a result, most areas of mangrove in Sembilang National Park experienced over the function and if not treated immediately then it is not impossible that mangroves will be completely depleted.

One of the efforts made to restore the mangrove is the approach followed by restoration with silvofishery system using "empang parit" pattern. Generally, silvofishery is the integration between brackishwater organism (*i.e*. milkfish) and mangrove in the same pond (Fitzgerald, 2002). This technique is considered the most suitable for ponds and expected social welfare can be increased while still ensuring proper mangrove forest sustainability (Surtida, 2000). Those silvofishery effort has been going on for the last 4 years and need for a study to determine the level of benefits of the mangroves on the ponds. Therefore, this study aimed to analyze the water quality and levels of nutrients (nitrate and phosphate) in the silvofishery ponds in Sembilang National Park, Banyuasin District.

Material and Methods

Sample collection

The study was conducted in October 2013 in Sembilang National Park, South Sumatra. At the park there are three large rivers, *i.e*. the Solok Buntu River, Barong Kecil River and Barong Besar River. On those three rivers there are ponds that use river water flow as a source of pond water (Figure 1).

In each region, water sampling and insitu measurements of parameters have been done using purposive sampling method. The sampling areas are silvofishery ponds, non-silvofishery ponds (restoration has not been done), and the rivers that the water flow into the pond. At Solok Buntu River and Barong Kecil River there are only 2 silvofishery ponds. On Barong Kecil River was taken 3 silvofishery ponds. In addition, sampling and measurement parameters were also performed on each river stream as a control.Sampling and measurement of insitu parameters at each sampling station using 3 different points. Sampling was conducted by carried out 50 ml of water which then directly kept in the cool box for nitrate and phosphate analyses in the laboratory. Insitu measurement of water parameters include temperature, salinity, pH, and dissolved oxygen (DO).

Figure 1. Research location at Sembilang National Park, South Sumatra

Results and Discussion

Insitu parameters

The measurements of insitu parameters was conducted to determine the condition of the water in each pond and river. Insitu parameter measurement results can be seen in Table 1. Table 1 shows the value of pH, DO, temperature, and salinity were different in each pond and river respectively. On Solok Buntu River and Barong Kecil River, pH in the silvofishery ponds was more alkaline than non-silvofishery ponds. This is presumably due to low CO_2 content in the pond restoration. At the time the study was conducted, silvofishery ponds are in post-harvest conditions, where there is no milkfish as culture organism and water conditions in the ponds are also in a little volume. This resulted in the absence of CO_2 source in the ponds so that the concentration of CO_2 was low.

Furthermore, the mangrove in the silvofishery ponds which also acts as the user CO_2 in water for photosynthesis, and those resulting lower CO_2. The function of mangrove as the absorber of CO_2 were also confirmed by Gonnea *et al*. (2004). High concentration of CO_2 will release more carbonate ions from calcium carbonate and the water will become more acid, and lower concentration of CO_2, the release of carbonate ions will be lower and pH waters will become more alkaline (Boyd, 1990). This is in accordance with Doney *et al*. (2009). In conmtrast, silvofishery ponds in Barong Besar River were found to be more acidic than non-silvofishery ponds. This is presumably due to the location of non-silvofishery ponds which are closer to the river as a water source. In addition, at the time of sampling, the silvofishery ponds were in dredged condition. It is thought to result in the release of the CO_2 content of the sediment to the water column and will effect on pH in ponds.

The pH of the river water bodies is generally lower than that of the ponds. The river is a source of CO_2 which was taken from the upstream to the downstream areas, and in addition that respiration which is carried out by the organism along the river bodies allegedly contributing to the increase in CO_2. Based on the government standard, pH conditions in the ponds that have been restored, natural ponds and river water bodies, tend to exceed the standard. The provisions KepMenLH No.51 of 2004 (standard for marine organism living) provides pH for quality standard in the range of 7 to 8.5, and Government Ordinance No. 20 of 1990 (standard for fisheries culture), provides pH in the range of 6 to 9. However, the condition exceeded standards this does not directly indicate that the condition of the silvofishery ponds are not suitable for the growth of milkfish. This is because post-harvest stages that occurring in the silvofishery ponds. While in the non-silvofishery ponds, the high pH conditions indicate that pond water conditions are in upper limit with the growth of milkfish. On the non-silvofishery ponds, people usually do not do water changes during cultivation. This is of course will result in declining of water quality little by little.

Influence of the presence of mangrove restoration in ponds is also seen in the content of DO, where DO of the silvofishery ponds are higher than non-silvofishery ponds or the river water bodies. This is caused by the photosynthetic activity by mangroves and transferred to the ponds water column. The conditions silvofishery ponds after harvest, causing the oxygen content of mangrove photosynthesis results are not fully utilized.

In addition, a higher pH level in the silvofishery ponds also affects the content of DO, pH the silvofishery ponds which are high (alkaline) will result in low CO_2 and high dissolved oxygen (Doney *et al*., 2009). The content of DO in the area of the ponds, both silvofishery and non- silvofishery, in Solok Buntu River and Barong Kecil River in accordance with the quality standards established by the Minister of Environment No. 51 of 2004 which is above 5 ppm, and established by Government Ordinance which is above 3 ppm. Whereas DO in all ponds in the Barong Besar River lower than the standard. Similarly, low level of DO in the silvofishery ponds due to the dredging stages of post-harvest, while the non-silvofishery ponds, indicating the need for the change of water to improve water quality.

The differences in the temperature parameter in the silvofishery ponds, non-silvofishery ponds and river water bodies, due to the difference time measurement parameters. Higher the inclination angle of the sun, cause higher water temperature. The ability of water to store heat also led to the temperature difference. This is presumably because of differences in water exchange processes. There are water changes regularly in the silvofishery ponds every high tide (once a month). But in the non-silvofishery ponds, water changes happen only once at the beginning of seeding.

The process of evaporation that occurs in ponds and the steady of water, resulting in increased salinity of non-silvofishery ponds. The salinity difference also happened between the silvofishery ponds and non-silvofishery ponds at Barong Besar River, because at the time of parameter measurement the silvofishery ponds underwent a water change from the water in the

Table 1. Insitu parameters of ponds and rivers in Sembilang National Park

Location		pH	DO (ppm)	Temperature (^{0}C)	Salinity (‰)
Solok Buntu River	Silvofishery ponds	9.61	7.54	35.53	21.67
	Non-silvofishery ponds	8.44	5.52	37.37	27.00
	River stream	8.18	3.12	31.49	15.00
Barong Kecil River	Silvofishery ponds	9.48	6.90	34.07	17.17
	Non-silvofishery ponds	8.95	5.01	38.72	23.00
	River stream	8.89	4.93	29.30	17.00
Barong Besar River	Silvofishery ponds	7.50	3.82	28.89	11.58
	Non-silvofishery ponds	8.94	3.76	29.57	8.67
	River stream	8.66	3.87	29.91	17.00

river. The differences of salinity value that occur in the river water bodies also affected by different time measurement. In this research, the measurements did not consider tidal conditions, which is water salinity will be higher at high tide than at low tide.

Nitrate and phosphate

Nitrate and phosphate are nutrient which become limiting factor of living organisms. Silvofishery ponds has the lowest nitrate and the highest phosphate concentration. Figure 2. Nitrate and phosphate in waters derived from the internal and external factors. Due to internal factors such as biochemical reactions and organism activity, while external factors such as land fill of waste carried by the flow of the rivers The high oxygen content in the water column of the silvofishery ponds, resulting in nitrification reaction which is perform by microorganisms that converts ammonia to ammonium which is then converted into nitrates (Schulz and Zabel, 2006). On the silvofishery ponds, nitrate formed is not only utilized by phytoplankton in the water column, it is also used in the mangrove photosynthetic process. In addition, nitrate is a protein that is essential for the growth of mangroves. Mangrove areas contained in the silvofishery ponds is a growing young mangrove. Sreeja *et al*. (2009) confirmed that same with other plants, the mangrove nitrate required for the biomass production as well as play an important role in the formation of green leaves that useful in the process of photosynthesis.

The higher of the nitrate uptake by plants, then the sooner the synthesis of carbohydrates are converted into protein for growth (Sutedjo and Kartasapoetra, 1990 in Latifa and Anggarwulan, 2009). This resulted in the concentration of nitrate in the silvofishery ponds remains low despite on going process of nitrification. Function of mangroves in reducing nitrate concentrations in this habitat is also confirmed by Reef *et al.* (2010). The highest nitrate concentration is in the body of the rivers. This is because more sources of nitrate (*i.e*. the input of additional land) and less use of nitrate.

Phosphate in the silvofishery ponds is the highest. This is because although phosphate is also one of the supporting elements of mangrove growth, but phosphate is more widely used to support for the formation of flowers and fruit, as well as the cell nucleus and the cell wall. Conditions of mangroves which are still classified in the seedlings category lead the phosphate absorption fewer than nitrate. In addition to mangroves, phosphate is also much used by other organisms. Nurjaya *et al*. (2009) describe that organisms using phosphate as a component of certain enzymes and proteins, adenosine triphosphate (ATP), ribonucleic acid (RNA), deoxyribonucleic acid (DNA), which is more needed by the organism as a source of energy in cellular metabolism. Conditions of silvofishery ponds which were freshly harvested also resulted in no organisms using phosphate significantly. It is different from the conditions of use of phosphates in the water bodies.

In addition to the above, the level of phosphate is also dependent on the pH of the waters in which at low pH, phosphates tend to form insoluble compounds. Sanusi and Putranto (2009) explains that the compounds are not soluble have tendency of occurrence in the aggregation process which then resulted the flocculants and settles into the sediment so the concentration in the water will also be low.

Table 2 shows that silvofishery ponds had the lowest concentrations of nitrate, but in general the non-silvofishery ponds had higher nitrate concentrations than the river water bodies. Non-silvofishery ponds are only used for milkfish cultivation, without the presence of plants. This resulted in the use of nitrates only do by a limited number of cultivated organisms. In contrast to river water bodies those have a greater number and variety of organisms. Moreover, judging from the content of DO (Table 1), higher nitrate concentration in the non-silvofishery ponds indicates that the internal source of nitrate (nitrification reaction) is also much more. This was due to higher DO will trigger the nitrifying microorganisms to perform faster reaction.

As for the concentration of phosphate, the concentration of the details in Table 2 is no different from the average phosphate generally in Figure 2, which has the highest concentration of the silvofishery ponds followed by phosphate concentration on non-silvofishery ponds and rivers water bodies is the lowest.

Nitrate content in the body of Solok Buntu River is much higher than the nitrates in the silvofishery ponds and non- silvofishery ponds (Table 2). This is thought to be due to the influence of high nitrate enter the water bodies. The number of active non-silvofishery ponds on Solok Buntu River are more than the number of non-silvofishery ponds on two other rivers. The plots of non-silvofishery ponds in Solok Buntu River contained different stages of culture. When research is done, there is some of non-silvofishery ponds were in the post-harvest stages. Conditions that the replacement water of the ponds only in the beginning of seeding, of course resulted in the wastewater pond after harvest contain low DO and high nitrate. When the pond water is discharged into the river, the nitrates in the ponds become one of input for nitrate in water bodies. Nitrate content contained in the area of non-silvofishery ponds and silvofishery ponds is still in standards range of KepMenLH No. 51 of 2004, *i.e.* a maximum of 0.008 ppm.

Based on these standards, the silvofishery ponds areas have nitrate concentration better for fish than non-restoration pond. Phosphate concentration area for all ponds, generally has exceeded the quality standard of KepMenLH No. 51 of 2004, *i.e.* a maximum of 0.015 ppm.

Nitrate concentration which are found in silvofishery ponds in Sembilang Nasional Park, also found similarly with nutrient concentration in silvofishery conducted in Tulang Bawang, Lampung Province (Miasto, 2010), silvofishery conducted in

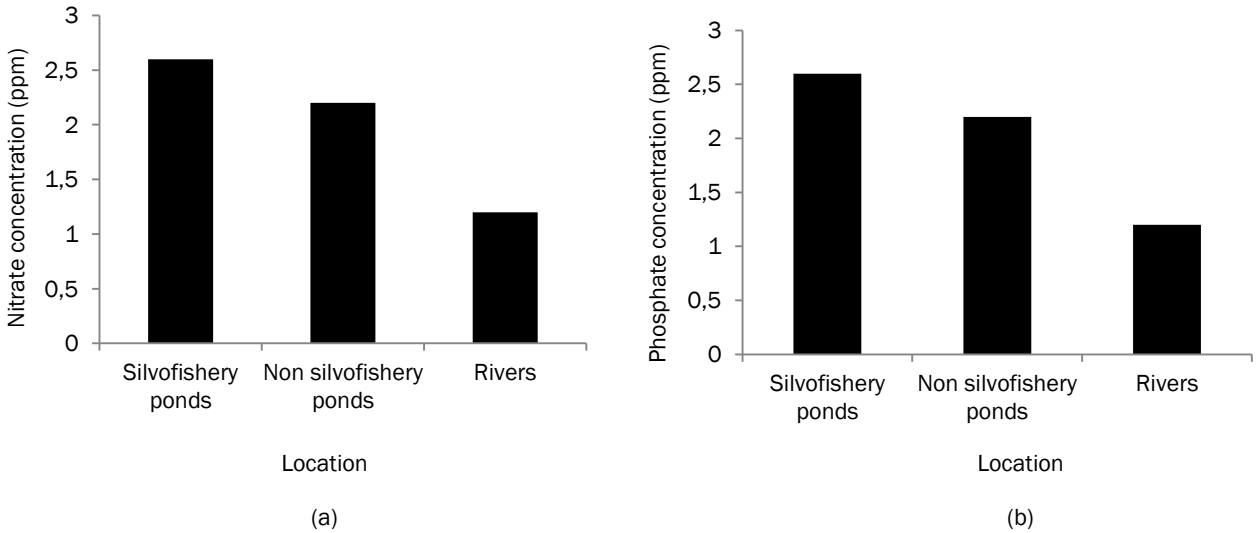

Figure 2. (a) The average of nitrate concentration (ppm); (b). The average of phosphate concentration (ppm) in the silvofishery ponds, non-silvofishery ponds, and river water bodies

Table 2. Nitrate and phosphate concentration (ppm) in ponds and river water bodies in Sembilang National Park

Location		Nitrate (ppm)	Phosphate (ppm)
Solok Buntu River	Silvofishery ponds	0.00326	2.84994
	Non-silvofishery ponds	0.00370	2.46205
	River stream	0.01460	0.05849
Barong Kecil River	Silvofishery ponds	0.00412	2.34938
	Non-silvofishery ponds	0.00746	3.44939
	River stream	0.00547	1.93806
Barong Besar River	Silvofishery ponds	0.00382	2.62299
	Non-silvofishery ponds	0.00563	0.60671
	River stream	0.00541	1.65658

Sinu Estuary, Carribean Coast of Colombia (Gautier, 2002), silvofishery in Grinting Village, Brebes Residence (Raharjo, 2003), and silvofishery in North Coast Area in Brebes Residence (Pudjiharjo, 2001). Those other silvofishery, there was also a decline in nitrate concentration because of the mangroves in the area of the ponds. But the pattern of phosphate concentration was different between silvofishery in Sembilang National Park and those other silvofishery. On those other silvofishery, the presence of mangroves caused an increase in the phosphate concentration. This is presumably because of the differences in the age of the mangrove, where mangroves were planted in the silvofishery ponds of Sembilang National Park is still young mangrove with less of leaves and roots.

However, this phenomenon only takes place when the mangroves are in a phase of young plants. Silvofishery which is used in mangrove restoration efforts in Sembilang National Park using the pattern "empang parit" which is a type 1 of pattern Silvofishery. This pattern utilizes waterways surrounding the pond as fish farming milkfish and mangrove planted in the middle area of the pond. The pattern of "empang parit" is using 60-80 % of the total area of ponds as mangrove planting (Bengen, 2000; Surtida, 2000; Fitzgerald, 2002). The existence of mangrove in the wide area of course will affect the nutrient conditions in the pond. Kathiresan and Bingham (2001) suggested that the presence of mangroves in an area of the pond would be better if less than 70% area of pond. Along with growth, mangrove pond will gradually dominate the pond area.

The mangrove dominance would likely result in decreased function of the mangrove as a provider of nutrients for the organism cultured. This is reinforced by Haris *et al*. (2013), where the size of the area of the pond is used for mangrove restoration resulted in the movement of organisms cultivated area will be narrow. In addition, mangrove in large numbers on farms indirectly will lead to higher potential to change the litter and sediment and water quality. Therefore, though silvofishery provide benefits for cultivation, but the composition of the mangrove area of the pond area should be considered.

Conclusion

Based on the results of the study it can be concluded that in general the existence of mangroves in the area of the ponds can improve the content of DO and pH of water ponds. Although the ponds being in the post-harvest stage, the silvofishery ponds are still able to be used as a cultivation area. Based from nitrate conditions, the silvofishery ponds suggest that mangroves in the area of the pond restoration showed satisfactory results in the capture of nitrate that would indirectly prevent the pond water from pollution. While based from phosphate conditions, the high phosphate in the area of the silvofishery ponds show that young mangrove plants have not been able to significantly phosphate binder.

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