



The Effect of Cage Culture on Water Quality of Laut Tawar Lake in Aceh Tengah District, Indonesia

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ABSTRACT

Cage culture is one of the ways to fulfill the needs of fish for the society. The cage culture can give some economical benefits for the farmers. However, the existence of the cage culture can also give some negative effects for the water quality of the lake. The sample of the water was analyzed from 2 stations; they were Station 1 which was the point outside the cage culture activity and Station 2 which was inside the cage culture activity. The parameters of the analyzed water quality were the temperature, brightness, turbidity, TSS, pH, DO, phosphate, N-amonia, N-nitrate, N-nitrites, coliform and E.coli. The result shows that, generally, the water quality of the lake is still in a good quality of the standard limitation. However, the existence of cage culture highly affects the reduction of water quality of the lake.

KEYWORDS

cage culture, station, water quality parameters.

1 Introduction

The needs of fish as one of the protein resources are increasing all over the world (Yee et al. 2012). The fish consumed by the people are from the sea and inland waterways. Especially for inland waterways, the fish are from a haul and aquaculture like the cage culture. Cage culture is one of the fairly ideal aquacultures located in the body of water such as inside the lake. One of the lakes used as the location of implementation of intensive system aquaculture in the form of cage culture is Laut Tawar Lake.

Laut Tawar Lake which has a water surface area of 5.742.10 Ha and the water area for haul of about ± 25,247 Ha is one of the lakes in Indonesia located in Aceh Tengah District (Husna et al. 2012; Kholik 2014). This lake serves about ± 64,147 people with an outlet crossing 5 districts/cities, includes Aceh Tengah, Bener Meriah, Bireuen, Aceh Utara and Lhokseumawe. The area of cage culture in Laut Tawar Lake is about ± 0.31 Ha with a growth rate of 4.74 % per year (Central Agency Statistics of Aceh Tengah District 2014).

The cage culture is one of the business units which can increase the economy of the society, especially for the society around the (Siagian et al. 2013). However, the existence of cage culture not only gives some economic benefits but also contributes in increasing the water pollution of the lake. The reducing water quality of the lake caused by the pollution will disrupt the life of many species include the endemic species. According to Muchlisin et al. (2011), one of the endemic species in Laut Tawar lake which is in endanger with a drastic reduction of the population in the last two decades is depik fish (*Rasbora tawarensis*). The production of depik fish through a haul in Laut Tawar Lake is continued to be

reduced every year. In 2007, the haul of depik fish reached 18,4 tons, in 2008 reached 15,0 tons, in 2009 reached 14,8 tons, and in 2011 only reached 8,6 tons (Livestock and Fisheries Department of Aceh Tengah District 2012). Contamination can lead to sudden death in fish and eutrophication in waters (Riani et al. 2014).

According to the result above, it needs to conduct an analysis on physical, chemical, and microbiological parameters of water quality of the lake, especially in the location of the cage culture. The result is expected to be one of the guides in arranging a strategy of lake management in the future.

2 Materials and Methodology

2.1 Research Location

The research was conducted in the aquaculture area in Laut Tawar Lake. The location of the cage culture administratively is located in Laut Tawar Sub-District: Station 1 is located on a coordinate of N 04° 36' 24.1" and E 96° 53' 32.8", while Station 2 is located on a coordinate of N 04° 36' 35.6" and E 96° 52' 2.2" (Figure 1). This research was conducted for six months, from July to December of 2014.

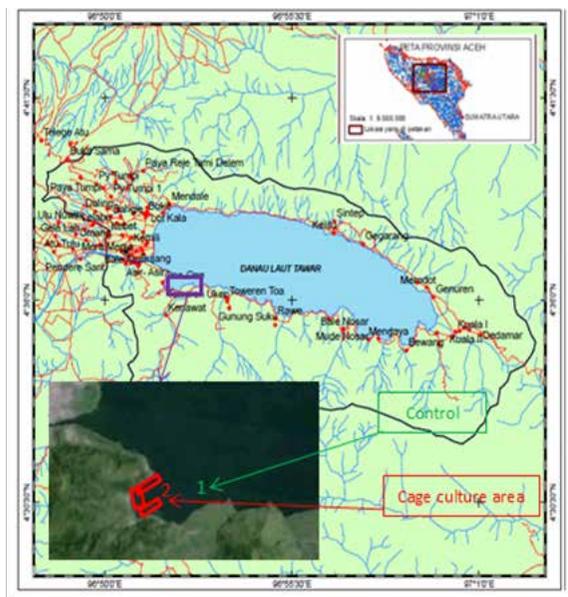


Figure 1. Research Location

2.2 Data Collection Technique

The physical, chemical, and microbiological data of the water were obtained from in-situ (direct measure) and ex-situ (laboratory) analysis. The samples of the water were taken from two stations, from Station 1 which was outside of the cage culture area and Station 2 which was in the area of the cage culture. Each water sample station was collected from three columns of water, i.e., the surface, the thermocline layer, and the lake base. The sampling method was conducted compositely which was by mixing the samples. The samplings of the lake water were conducted twice in July and October of 2014.

2.3 Analysis of Physical, Chemical and Microbiological Parameters of Water Quality

The analyzed physical, chemical, and microbiological parameters were the temperature, transparency, turbidity, TSS, pH, DO, phosphate, N-ammonia, N-nitrate, N-nitrites, coliform and E.coli. Analysis of varians (ANOVA) was conducted to check whether there was any difference of the water quality in Station 1 and 2 by using the data analysis tools from Microsoft Excel 2010. The analysis of water quality was conducted by comparing the data of the test result of water quality with the water quality constant by EPA (2001) and Boyd (1982).

3 Results

The results of physical, chemical and microbiological parameters tests of the water samples from two stations in the aquaculture area in Laut Tawar Lake are presented in Table 1. The result of analysis of variance (ANOVA) shows that there was no significant difference between the water quality in Station 1 and 2 ($p > 0.05$), but there was a reduction in several parameters of water quality in Station 2 as the effect of the existence of the cage culture in Laut Tawar Lake. This water quality reduction is known from the changes of parameters concentration of the water sample in Station 2.

The mean of water temperature in both stations is relatively stable of 23.60 °C. The mean of water brightness is ranging from 465-528 cm. The mean of water turbidity is ranging from 1.03 – 1.29 NTU. The mean of TSS concentration of the water is 1.17-1.74 mg/l. The mean of water pH is ranging from 8.17 – 8.20. The mean of dissolved oxygen of the water is ranging from 5.28 – 6.28 mg/l. The mean of phosphate of the water is ranging from 0.15– 0.22 mg/l. The mean of ammonia of the water is 0.002 mg/l. The mean of nitrate of the water is ranging from 0.55 – 1.59 mg/l. The mean of nitrites of the water is ranging from 0.009 – 0.013 mg/l. The mean of coliform bacteria is ranging from 5 – 18 MPN/100 ml. The mean of E. coli bacteria is ranging from 4 – 11 MPN/100 ml.

Parameters	Unit	Station 1	Station 2
		Mean±SD	Mean±SD
Temperature	°C	23.60±1.70	23.60±0.28
Transparency	cm	528±130.11	465±127.53
Turbidity	NTU	1.03±0.11	1.29±0.21
TSS	mg/l	1.17±0.94	1.74±1.51
pH		8.20±0.06	8.17±0.02
DO	mg/l	6.28±0.50	5.28±0.26
Phosphates	mg/l	0.15±0.08	0.22±0.06
Ammonia	mg/l	0.002±0.001	0.002±0.001
Nitrate	mg/l	0.55±0.49	1.59±0.69
Nitrite	mg/l	0.009±0.001	0.013±0.004
Coliform	MPN/100 ml	5±3	18±4
E. coli	MPN/100 ml	4±1	11±6

Note : Station 1 : Outside the cage culture area (control), Station 2 : Inside the cage culture area

4 Discussion

Theoretically, the activity of cage culture has an effect on the reduction of lake water quality, includes the increase of eutrophication process, pH changes, and the possibility of the increase of toxicity of unionized ammonia and nitrites. (Gorlach et al. 2013). In the other hand, the cage culture also requires a good water quality (Buyukcapar & Alp 2006). Based on the results of the measure in both stations, the mean of the temperature is relatively similar with the bigger range in Station 1. The temperature in Station 2 is relatively higher than in Station 1 (Zanatta et al. 2010; Ayokunmi & Aghatise 2014). It is caused by the activity of microorganism which decomposed the residual of the fish feed which results in CO₂, thus, it has an impact on the increase of lake water temperature. The temperature affects the growth and life of the biota in the water. The drastic changes of water temperature can cause stress and death to the biota. The temperature affects the organisms' metabolism activities and solubility of the gases includes the concentration of the dissolved oxygen and also the decomposition process of organic materials by the microbes in the water. The range of temperature in both stations is still normal which is not higher than 25 °C (EPA 2001).

The brightness is a water transparency measure. The water brightness depends on the color and turbidity. The higher level of brightness shows the low level of mud contents or turbidity of lake water. The standard of water quality for brightness parameter is should be ≥ 1 m (EPA 2001). The brightness in Station 2 is relatively lower than in Station 1 (Zanatta et al. 2010; Ayokunmi & Aghatise 2014). It is caused by the residual of the feed which is not fed by the fish which can increase the color and turbidity of the water. The turbidity reflects the existence of dissolved and suspended organic and inorganic materials and also the planktons and other microorganisms. The turbidity has a positive relationship with the total suspended solid, but not with the dissolved ones. The range of turbidity in both stations is still relatively safe for the drinking water with the allowed maximum level which is 10 NTU (EPA 2001).

The Total Suspended Solid (TSS) is a solid which can affect the water turbidity, cannot be dissolved and directly sedimented which consists of particles with the diameters of >10⁻³ mm. The range of mean of TSS in both stations is still very low compared to the water quality standard of EPA (2001) which is 50 mg/l. The concentration of TSS in Station 2 is relatively higher than in Station 1 (Ayokunmi & Aghatise 2014). The un-dissolved fish feed residue in the water can increase the concentration of TSS.

pH is the illustration of hydrogen ion concentration. The range of pH in the lake is still in a good growth level (Boyd 1982). The relatively higher range of pH in the water is caused by the forming of the lake which was formed by the volcanic activity. It is alleged that this lake contains high calcium contents. Calcium contained water is usually has a higher concentration of bicarbonate and carbonate. The existence of these compounds can increase the pH value in the water.

The dissolved oxygen is needed by the biota in the water for breathing. It is resourced from the photosynthetic and diffusion of the oxygen in the atmosphere. The lowest value of dissolved oxygen is in Station 2 (Zanatta et al. 2010; Ayokunmi & Aghatise 2014). It is caused by the accumulation of fish feed in the base of the lake which are not fed by the fish, which naturally will be decomposed by the microorganisms in the base of the lake. In an aerobic situation, the decomposition process needs sufficient oxygen, thus, the availability of the dissolved oxygen will be reduced. However, the range of dissolved oxygen does not meet the water quality standard in the dry season, which is ≤ 5.22 (EPA 2001).

The concentration of phosphate in both stations is still in a good level of water quality standard of ≤ 0.5 mg/l (EPA 2001). The mean of phosphate in Station 2 is higher than in Station 1 (Alpaslan & Pulatsu 2008; Zanatta et al. 2010). The cage culture activity which uses pellet as the fish feed has an impact on the increase of phosphate concentration in the water. The range of ammonia concentration in both stations is still in a good level of water quality standard of ≤ 0.2 mg/l (EPA 2001).

Nitrate is an important nutrient for the growth of plants in the water. In an aerobic situation or sufficient dissolved oxygen, the protein will be degraded by microorganisms into ammonia which later in the nitrification process will be oxidized into nitrate. The concentration of nitrate in both stations is still in a good level of water quality standard of ≤ 50 mg/l (EPA 2001). The concentration of nitrate in Station 2 is relatively higher than in Station 1 (Ayokunmi & Aghatise 2014).

The concentration of nitrites in both stations is still in a good level of water quality standard of ≤ 0.05 mg/l (EPA 2001). Station 2 has nitrites relatively higher than in Station 1. It is caused by the organic materials as the residue of fish feed in a oxygen sufficed or aerobic situation which will be decomposed by microorganisms into ammonia to nitrites and ended as nitrate, CO_2 and H_2O . In an anaerobic situation, the organic materials are decomposed into methane, ammonia, H_2S , CO_2 and H_2O . In addition, there will be a denitrification in the water, in which nitrate will be decomposed into nitrites and ammonia. It is alleged as the cause of the high nitrite concentration in Station 2.

Both stations has an amount of coliform bacteria in which is still in a good level of water quality standard of $\leq 5,000$ MPN/100 ml (EPA 2001). The amount of coliform bacteria in Station 2 is relatively higher because of the feces waste from the cage culture activity. The amount of E. Colibacteria in both stations is still in a good level of water quality standard of $\leq 1,000$ MPN/100 ml (EPA 2001).

5. Conclusion

The existence of cage culture in The Laut Tawar Lake 0.31 Ha area has not shown a significant decline in water quality ($p > 0.05$). However, based on parameters such as transparency, turbidity, TSS, DO, phosphate, nitrate and nitrites in two stations, have different areas where the concentration of cage culture with declining water quality.

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