Application of Aeration Injection to Increase Dissolved Oxygen of Surface Water in The Floating Net Cage

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Abstract. Cirata Reservoir is a place for fish cultivators who mostly cultivate tilapia using floating net cages. However, water quality conditions, especially dissolved oxygen levels, which play an important role in tilapia culture in floating net cages are always uncertain and affect the growth of tilapia. Therefore, artificial aeration is needed that is able to increase dissolved oxygen levels so that it is suitable for tilapia culture by using Aerator Dua Lapis (ADL) engine. This study aims to inject dissolved oxygen into the surface layer of the reservoir by applying the ADL engine with gasoline. ADL operated at 1800, 4500, and 5500 rpm with a torque of 3.5 N/m² and the DO value is recorded every 10 minutes up to 1440 minutes, the results of DO value were recorded and analyzed by using descriptive statistic and statistically using ANOVA with a single factor showed that the rotation has a very significant effect on the resulting DO value (p<0.01). For ADL operation in floating net cages, 4500 rpm rotation was used at certain depth (0.4 m; 1 m; 1.5 m) and the DO value measured at 4.00 am to 2.00 am (22 hours) in aerated floating net cages and without aerated floating net cages. Aerated floating net cages have a higher DO value, especially at a depth of 0.4 m. ADL as an aerator in floating net cages has a very significant effect (p<0.01) in increasing the DO value in floating net cages at a depth of 40 cm to 1.5 m. This proved that the use of ADL is able to increase the DO value in floating net cages in the first layer with a depth of up to 4 m and ADL also can be used as emergency aeration or supplemental aeration for tilapia culture.

1. Introduction
Cirata Reservoir is a man-made reservoir located in West Bandung District, West Java Province at an altitude of 700 above sea level [1]. Cirata Reservoir is a place for fish cultivators who mostly cultivate tilapia using floating net cages [2][3][4][5]. In general, the phenomenon in the Cirata Reservoir concentration of dissolved oxygen is produced from the photosynthesis process of aquatic plants and phytoplankton during the day. The sun shining on the surface of the water results in an increase in the surface temperature of the reservoir water. As the temperature increases, the amount of oxygen that can be dissolved in the water decreases. Thus, the ability of dissolved oxygen in water is strongly influenced by water temperature. Dissolved oxygen levels will decrease at night because it is used for respiration of aquatic organisms including tilapia in the Floating Net Cages (FNC) without oxygen supply from photosynthesis, including decomposer bacteria that also consume oxygen in the water.
Tolerance of oxygen levels of tilapia in the FNC in order to survive and swim behavior not on the surface of the water is more than 5 mgL$^{-1}$ [6]. However, the excess dissolved oxygen concentration causes death by the occurrence of embolism in the blood vessels due to too many air bubbles (gas bubble disease) [7][8].

The need for oxygen in fish cages is highly dependent on factors of temperature, pH, CO$_2$, and the metabolic rate of the fish. Important factors are water temperature and body weight. The need for oxygen increases with increasing water temperature. Body weight will be related to activity and will increase respiration. The higher the weight, the lower the need for oxygen. Fish metabolism will decrease/stop when the temperature is not optimal or the changes are too extreme. If the water temperature increases, the amount of oxygen content decreases and oxygen consumption by fish in the water increases. The reduced oxygen has an impact on the fish's activity decreasing or stopping because their appetite stops. The impact of lack of oxygen on fish is disorientation of fish swimming, uneven activity of inhabiting the water column and death [9].

Another consequence of fish will not take after food so that fish look for places that have a lot of oxygen such as to the surface of the water or around the water intake. However, water quality conditions, especially dissolved oxygen levels, which play an important role in tilapia culture in floating net cages are always uncertain and affect the growth of tilapia. Therefore, artificial aeration is needed that is able to increase dissolved oxygen levels so that it is suitable for tilapia culture. Through a two-layer aerator (Aerator Dual Lapis/ADL) that was operated on the surface of the water of the FNC, air was injected into the water column on the surface of the water actively as an emergency effort to provide dissolved oxygen quickly. This ADL is a way of controlling the problem of lack of oxygen on the surface of the FNC water during an emergency condition through continuous rotation of the impeller to produce aeration from the air flow to the Venturi pipe.

2. Materials and Methods

1.1. Study site
The Two-Layer Aeration Test on the surface layer of the floating net cage was carried out during the transition season when dissolved oxygen in the water decreased. Aerator Dua Lapis (ADL) setup was done on the cage in Cirata reservoir/dam that can be seen in Figure 1.

1.2. Specification of ADL
Aerator Dua Lapis (ADL) that will be tested in floating net cage in Cirata reservoir was shown in Figure 2, ADL configuration was shown in Figure 3 and its specification was shown in Table 1.

1.3. In-situ measurement
The ADL was operated at 1800, 4500, and 5500 rpm with a torque of 3.5 N/m$^2$ and the DO value was recorded every 10 minutes up to 1440 minutes. Then, to operate ADL in floating net cages, the ADL was run from 04.00 – 02.00 (22 hours) at a constant rotation of 4500 rpm and the DO value was measured for a certain depth (0.4 m; 1 m; 1.5 m) using a DO meter (YSI Pro20) in aerated and non-aerated floating net cages.
Figure 1. Cirata reservoir [10]

Figure 2. ADL in floating net cage area in Cirata reservoir
Figure 3. Configuration of Aerator Dua Lapis (ADL)

Table 1. Specification of machine for operating air injection

| Merk          | Honda GXV160          |
|---------------|-----------------------|
| Type          | 4 Stroke, OHV          |
| Output Power  | 4.3 HP (3.2 KW) at 3600 rpm |
| Displacement  | 163 cc                |
| System starting | Recoil               |
| Ignition      | Transitorized Magneto |
| Fuel          | Gasoline              |
| Fuel Capacity | 2 Liter               |

3. Result and Discussions
Research on the quality phenomenon in the Cirata reservoir and its impact on fisheries has been carried out by many researchers both at home and abroad [1][2][3][4][5][11][12][13]. One of the important parameters to be observed is dissolved oxygen levels. This is because oxygen levels are an important parameter in fish growth [14][15][16][17][18][19]. Although dissolved oxygen levels played an important role in life in water, there were still some fishes that can survive in low oxygen levels [20][21]. This condition with dissolved oxygen levels was called hypoxia. According to Prakoso's research, that continuous hypoxic conditions have a negative effect on the movement of tilapia fry and subsequently lead to death [22]. Therefore, one action was needed to reduce fish mortality due to hypoxia or upwelling, namely by using an aeration system that functions as an emergency aeration [23].

After operating ADL at 1800, 4500, and 5500 rpm with a torque of 3.5 N/m² and the DO value is recorded every 10 minutes up to 1440 minutes, the results of DO value were shown in Figure 4 and for descriptive statistics were shown in Table 2.
Table 2. Results of DO value at 1800 rpm; 4500 rpm; and 5500 rpm with torque 3.5 N/m²

| Rotation (rpm) | Mean       | Min – Max | Standard Deviation | Variance       | Anova with single factor (p value) |
|---------------|------------|-----------|--------------------|----------------|-----------------------------------|
| 1800          | 4.111111111| 3 - 4.8   | 0.442040898        | 0.195400155    | 1.32E-33                          |
| 4500          | 4.445139   | 3.3 - 5.8 | 0.741934           | 0.550465715    |                                   |
| 5500          | 5.1625     | 4 - 6.6   | 0.792083           | 0.627395105    |                                   |

Figure 4 showed that the larger the engine speed, the higher the DO value or linearly proportional. In Figure 4, the DO value for 4500 rpm and 5500 rpm did not have a big difference from the beginning of operation until the 360th minute, but this did not happen at 1800 rpm. Even though at 5500 rpm it produced a large DO value, it resulted in large gasoline consumption. So, for ADL operation in floating net cages, 4500 rpm rotation was used as the optimal rotation.

Table 2 showed descriptive statistics of DO values at different speeds (1800, 4500, and 5500 rpm). Table 2 showed that 1800 rpm rotation produced DO values with low standard deviation and variance when compared to 4500 rpm and 5500 rpm rotations and statistically using ANOVA with a single factor showed that the rotation has a very significant effect on the resulting DO value (p < 0.01)
Table 3. Results of t-test for two samples with assuming equal variances

| Depth (m) | Hour       | Cage with no aeration (min – max) | Cage with aeration (min – max) | p value         |
|-----------|------------|----------------------------------|-------------------------------|----------------|
| 0.4       | 04.00 - 02.00 | 1.7 – 3.2                        | 4 – 5.5                       | 6.56247E-15    |
| 1         | 04.00 - 02.00 | 1.6 – 2.5                        | 2.2 – 4.3                     | 1.93135E-08    |
| 1.5       | 04.00 - 02.00 | 1.1 – 2.2                        | 2 – 3.5                       | 2.21009E-06    |
| 0.4 – 1.5 | 04.00 - 02.00 | 1.1 – 3.2                        | 2 – 5.5                       | 8.84797E-16    |

Figure 5 showed the DO value measured at 4 to 3 hours in aerated floating net cages at a certain depth (0.4 m; 1 m; 1.5 m) with aerated floating net cages. Figure 5 also showed that aerated floating net cages have a higher DO value, especially at a depth of 0.4 m.

Table 3 showed that the use of ADL as an aerator in floating net cages has a very significant effect (p<0.01) in increasing the DO value in floating net cages at a depth of 40 cm to 1.5 m. This proved that the use of ADL is able to increase the DO value in floating net cages in the first layer with a depth of up to 4 m which is a place for carp (Cyprinus carpio) farming. [1][2][3].

The use of aeration strategies, either emergency or supplemental, has been tested in intensive culture of tambaqui and emergency aeration (aeration system was activated with DO levels < 3 mgL⁻¹) showed better growth performance than supplemental aeration (8 hours of aeration every night and also during days with low solar radiation) [24]. According to the results that showed in Figure 4-5 and Table 2-3, the use of ADL can be used as emergency aerator or supplemental aerator for tilapia culture in the Floating Net Cages (FNC).

4. Conclusion
Aerator Dua Lapis (ADL) based on air injection aeration by using machine has been effective and proven for surface aeration at a certain depth 0.4 m; 1 m; and 1.5 m. The high value of DO generated using ADL is directly proportional/linear to the engine speed that is run and of course will have an impact on fuel use. ADL also can be used as emergency aeration or supplemental aeration for tilapia culture.

Acknowledgment
We are thankful to Asosiasi Pembudidaya Ikan dan Nelayan Waduk Cirata (Asindac) for their cooperation in testing the use of ADL (Aerator Dua Lapis) tool in tilapia floating net cages. We also say thank you to Dinas Perikanan dan Peternakan Kabupaten Bandung Barat whom facilitated and helped the ADL experiment until it was accomplished successfully.

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