# The Impact of Floating Net Cage (FNC) on Primary Productivity in Cirata Reservoir Waters

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## ABSTRACT

Cirata Reservoir is one of the three cascade reservoirs fed by the Citarum Watershed with an area of 62 km2 (6.200 ha) and has a water volume of 1.900 million m3. The great potential of the waters in the Cirata Reservoir is utilized by the local community as a source of livelihood, namely by conducting aquaculture activities using floating net cages (FNC) in excess. FNC is thought to be a source of waste that reduces reservoir water quality. This research aims to determine the impact of FNC cultivation on primary productivity with different FNC densities at each station. The research was conducted in Cianjur Regency by taking on three stations, namely in the areas of Jangari, Maleber, and Patok Beusi on November 6 - December 8, 2019. The method used in the research was purposive sampling then analyzed in detail and quantitatively. The results show that reservoir waters have an average of physical parameters, namely temperature 32.2-32.6oC, transparency 0.59-0.68 meters, pH 7.1-7.3, carbon dioxide 15.4-16.1 mg / l, Dissolved Oxygen 6.9-7.3 mg / l, Biochemical Oxygen Demand 6.1-7.8 mg / l, nitrate 0.208-0.222 mg / l, ammonia 0.002833-0.003056 mg / l, phosphate 0,165-0,167 mg / l and primary productivity 240,36-277,90 mgC/m$^3$/hour. This shows that the water indicator is still classified as good because it does not exceed the water quality standard.

*Keywords: Fish; reservoir; waste; water quality.*

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## 1. INTRODUCTION

Cirata Reservoir flows through three regencies, namely Cianjur, Purwakarta, and West Bandung Regency. This reservoir functions as a hydropower plant in Southeast Asia and has the potential to carry out fishery activities. People who live around the reservoir use it a lot for aquaculture using floating net cages (FNC). The number of floating net cage in Cirata Reservoir has increased every year. The census conducted by the Badan Pengelola Waduk Corata in 2018 reached 98,397 units [1]. The maximum limit allowed is only 12,000 units [2], and has been revised to 7,204 units [3]. Based on this, it can be seen that the number of floating net cages in Cirata Reservoir has exceeded the predetermined limit. Excessive numbers of floating net cage can increase sedimentation and decrease the quality of water that comes from the feed given to the floating net cage[4]. In addition, the largest N and P contributors, reaching 99,97% and 98,63% came from fish farming activities in KJA [5]. The total amount of feed given per day reaches 3% of the fish weight, while the feed that is not consumed by fish is estimated at 20% - 25%.

If not handled seriously, various sources of waste input to Cirata Reservoir will disrupt the main function of the reservoir and increase pollution which impacts aquatic organisms. One of the ways to determine whether the waters are polluted or not is by knowing the primary productivity and water quality around the floating net cage. Therefore, it is necessary to conduct a study on the impact of FNC cultivation on the primary productivity of the waters so that it becomes a reference in evaluating the feasibility and management of floating net cages (FNC) in Cirata Reservoir. The purpose of this research is to determine the impact of KJA's presence on primary productivity in Cirata Reservoir waters so that it can be used as a reference in evaluating the feasibility and management of KJA.

## 2. MATERIALS AND METHODS

This research was conducted in Cirata Reservoir, Cianjur Regency, West Java. The research was conducted on November 6 - December 8, 2019. Research observations were carried out in situ in Cirata Reservoir and exitually at the Water Resources Laboratory (SDP) of the Faculty of Fisheries and Marine Sciences, Padjadjaran University, Jatinangor. The method used in this research is purposive sampling method, namely determining the location points with different density of floating net cage.

The location of the collection consists of 3 stations, including 1 block Jangari station located in Mande District which borders on Ciranjang District. The number of FNC was 3,584 units. Station 2 block Maleber is in Mande District bordering Cikalong Kulon District with 2,075 units of FNC. Station 3 block Patok Beusi is in Cikalong Kulon District bordering Purwakarta Regency with 2,268 units of FNC [5]. Sampling was done 6 times with a frequency of 7 days.
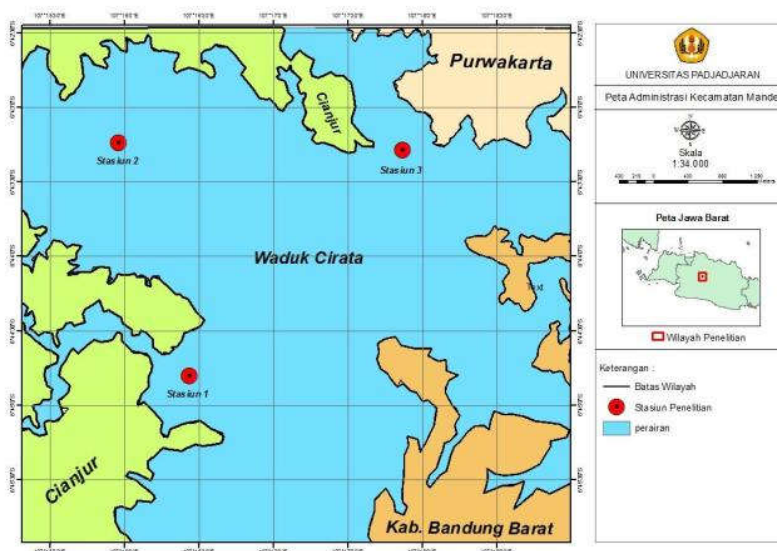


**Fig. 1. Research location map**

## 2.1 Research Procedure

### 2.1.1 Taking water samples

Water samples were taken at different depths, namely on the surface, compensation and under compensation. Compensated depth is the depth below the surface, calculated using the formula [6] :

Depth of compensation = 4.6 / k

* The attenuation coefficient of the disc depth reading using the empirical equation [7] as follows:

k = 0.191 + 1.242 / Zsd

Information:

k = attenuation coefficient (m-1),

Zsd = disk secchi depth (m).

Meanwhile, the depth below compensation is the lower limit of the depth of the FNC (1 meter below the compensation depth).

### 2.1.2 Primary productivity measurement of aquatic

Primary productivity measurement in Cirata Reservoir uses the winkler method. Winkler method is a measurement method that is often used, because besides being relatively cheap it is also quite accurate, especially in productive waters [8]. The formula used in the calculation is [9] :

$FB = (O_2 \text{ in } BB - O_2 \text{ in } DB) \times 1000 / ((PC)(t)) \times 0.375$

Information:

FB: Net Photosynthesis (mgC / m$^3$ / hour)

O2: Dissolved oxygen (mg / l)

BB: Bright Bottle

DB: Dark Bottle

PC: Photosynthesis Coefficient (1,2)

t: Incubation time (hours)

The bottles used in the study consisted of a light bottle, a dark bottle and an initial DO. All bottles were incubated for approximately 4 hours in the water. such as research conducted in measuring the primary productivity of waters using the light and dark bottle method [7]. DO in waters must be immediately tied up to measure the change, then MNSO4 and O2 reagents are used, then taken to the SDP laboratory to be titrated and the DO levels are calculated.

### 2.1.3 Measurement of physical and chemical parameters

The physical and chemical parameters of the waters are divided into 2, some are measured in situ, some are measured in the laboratory. This is shown in Table 1.

## 3. RESULTS AND DISCUSSION

The primary productivity measurement experiences different values each week, this is due to differences in the activity of aquatic organisms such as the consumption of dissolved oxygen by bacteria.

**Table 1. Sampling units, tools, methods and locations**

| Parameters | Unit | Tool | Method | Location |
|---|---|---|---|---|
| **Physical** | | | | |
| Temperature | $^o$C | Thermometer | Potentiometric | *In Situ* |
| Transparency | m | *Secchi Disc* | Visual | *In Situ* |
| **Chemical** | | | | |
| pH | - | pH meter | Potentiometric | *In Situ* |
| $CO_2$ | mg/L | Erlenmeyer Glass | Titration | *In Situ* |
| $BOD_5$ | mg/L | Winkler Bottle | Iodometry | Laboratory |
| DO | mg/L | Winkler Bottle | Titration | *In Situ* |
| Ammonia | mg/L | Spectrophotometer | Spectrophotometric | Laboratory |
| Nitrate | mg/L | Spectrophotometer | Spectrophotometric | Laboratory |
| Phosphate | mg/L | Spectrophotometer | Spectrophotometric | Laboratory |

**Table 2. Primary productivity average value**

| Station | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Average |
|---------|--------|--------|--------|--------|--------|--------|---------|
| 1A | 202,34 | 430,86 | 227,34 | 248,83 | 253,13 | 189,45 | 258,66 |
| 1B | 228,13 | 442,58 | 257,81 | 278,52 | 253,13 | 113,67 | 262,30 |
| 1C | 253,13 | 341,80 | 228,13 | 240,63 | 202,34 | 139,45 | 234,24 |
| 2A | 404,69 | 265,63 | 303,13 | 468,36 | 228,13 | 240,63 | 318,42 |
| 2B | 379,69 | 227,73 | 253,13 | 442,58 | 76,56 | 126,17 | 250,98 |
| 2C | 253,13 | 252,73 | 100,78 | 139,06 | 75,78 | 88,67 | 151,69 |
| 3A | 207,03 | 415,63 | 353,91 | 341,41 | 379,69 | 380,08 | 346,29 |
| 3B | 202,34 | 342,19 | 379,69 | 114,06 | 303,91 | 139,06 | 246,88 |
| 3C | 253,13 | 253,13 | 329,69 | 215,23 | 202,34 | 189,84 | 240,56 |

*Information:*
*A = Surface*
*B = Compensation*
*C = Lower Compensation (+ 1m)*

**Table 3. Water quality data at each depth**

| Parameters | Depth | Station | | |
|------------|-------|---------|---------|---------|
| | | **1** | **2** | **3** |
| Temperature ($^{o}C$) | S | 32,9 | 33 | 33,3 |
| | C | 32,3 | 32,2 | 32,5 |
| | UC | 31,5 | 31,7 | 32,1 |
| Transparency (m) | S | 0,62 | 0,68 | 0,59 |
| pH | S | 7,2 | 7,2 | 7,5 |
| | C | 7 | 7 | 7,1 |
| | UC | 7,1 | 7 | 7,2 |
| DO (mg/l) | S | 8,8 | 8,7 | 8 |
| | C | 7,5 | 6,6 | 7,1 |
| | UC | 5,6 | 5,2 | 6,2 |
| BOD (mg/l) | S | 7,2 | 8,3 | 7,2 |
| | C | 7,7 | 5,2 | 7,9 |
| | UC | 6,4 | 4,8 | 8,3 |
| $CO_2$ (mg/l) | S | 11,2 | 13,3 | 11,9 |
| | C | 16,8 | 15,4 | 15,4 |
| | UC | 20,3 | 19,6 | 18,9 |
| Ammonia (mg/l) | S | 0,003 | 0,004 | 0,004 |
| | C | 0,003 | 0,003 | 0,003 |
| | UC | 0,003 | 0,003 | 0,002 |
| Nitrate (mg/l) | S | 0,197 | 0,204 | 0,192 |
| | C | 0,203 | 0,232 | 0,223 |
| | UC | 0,223 | 0,231 | 0,243 |
| Phospate (mg/l) | S | 0,171 | 0,162 | 0,167 |
| | C | 0,172 | 0,178 | 0,168 |
| | UC | 0,16 | 0,159 | 0,164 |

*Information:*
*S: Surface*
*C: Compensation*
*UC: Under Compensation*

**Table 4. Average water quality and optimal range**

| No | Parameters | Station | | | Optimal Range |
|---|---|---|---|---|---|
| | | I | II | III | |
| | **Physical** | | | | |
| 1. | Temperature ($^oC$) | 32,2 | 32,3 | 32,6 | 20-30* |
| 2. | Transparency (m) | 0,62 | 0,68 | 0,59 | - |
| | **Chemical** | | | | |
| 3. | pH | 7,1 | 7,1 | 7,3 | 6-9* |
| 4. | DO (mg/l) | 7,3 | 6,9 | 7,1 | 3-4* |
| 5. | BOD (mg/l) | 7,1 | 6,1 | 7,8 | 3-6* |
| 6. | $CO_2$ | 16,1 | 16,1 | 15,4 | 50* |
| 7. | Ammonia (mg/l) | 0,00283 | 0,00288 | 0,00305 | 0,02* |
| 8. | Nitrate (mg/l) | 0,208 | 0,222 | 0,219 | 10* |
| 9. | Phospate (mg/l) | 0,167 | 0,165 | 0,166 | 0,2* |

*Information:*
*\*Government Regulation (GR) Number 82 Year 2001 Class II and III*

Primary productivity in Cirata Reservoir ranges from 240.36 to 277.90 mgC / m$^3$ / hour. Based on these results, it can be categorized that the waters of the Cirata Reservoir based on the primary productivity of the waters are included in mesotrophic, namely waters with good (moderate) fertility. Primary productivity can be used to determine the fusion of a waters [10]. The classification of fertility levels is: 0-200 mg C / m$^3$ / day including oligotrophic, 200-750 mg C / m3 / day including mesotrophic and more than 750 mg C / m3 / day including eutrophic [10].

The highest station productivity value is at station 3, receiving the most dissolved nutrients from stations 1 and 2. The amount of primary productivity of a water indicates the amount of dissolved nutrient availability [11]. The amount of primary productivity is influenced by the number of organisms that carry out the photosynthetic process such as phytoplankton. The number of phytoplankton in the Cirata Reservoir, Cianjur Regency, in the Patok Beusi area is more than Maleber and Jangari [12]. The amount of primary productivity of a waters can indicate the large availability of dissolved nutrients in these waters [13].

Measurement of water quality in Cirata Reservoir is compared with the water quality standards listed in Government Regulation Number 82 of 2001 class II and III. Based on the data above, the water quality in Cirata Reservoir is classified as suitable for fish farming activities, because most of the parameters do not exceed the water quality standard.

The temperature in the Cirata Reservoir is 32.2-32.6oC. This temperature is high because in general the surface temperature of the waters in Indonesia is between 28 - 31°C [14]. The upper layer of the water has a higher (hotter) temperature than the water layer below it, meaning that the deeper the water is, the lower the temperature [15]. The average change for each station is not much different, at station 1 shows a value ranging from 31.5 to 32.9$^oC$, station 2 shows a value ranging from 31.7 to 33$^oC$ and station 3 shows a value ranging from 32.1-33.3$^oC$. The changes in water temperature are caused by high light intensity, which then produces heat which in turn will increase the temperature and vice versa [16].

The transparency value of Cirata Reservoir is 0.59-0.68 m. Station 1 has an average transparency of 0.62 m, at station 2 is 0.68 m and at station 3 is 0.59 m. In transparency there is no minimum quality standard, but it still affects other parameters. The level of transparency are influenced by turbidity. High turbidity can inhibit light penetration into the water [15].

The pH value of Cirata Reservoir is 7.1-7.3. Station 1 shows a value ranging from 7-7.2, station 2 shows a value ranging from 7-7.2 and at station 3 shows a value ranging from 7.1 to 7.5. On surface waters, pH is higher (alkaline) than the compensation depth and under compensation. This is because algae receive inorganic carbon from bicarbonate ions in the photosynthesis process which increases the number of hydroxyl ions in the waters [17]. The increase in pH value in the study was caused by the occurrence of photosynthesis during the day. The process of photosynthesis utilizes carbon dioxide as a raw material, which causes a decrease in the carbon dioxide content in the

water. In addition, the research found that in deeper waters, the pH was lower. The decrease in pH at the bottom is due to increased microbial activity to break down organic matter which results in decreased oxygen ($O_2$) and increased carbon dioxide ($CO_2$) [18].

The $CO_2$ value of Cirata Reservoir is 15.4-16.1 mg / l, Station 1 shows a value ranging from 11.2 to 20.3 mg / l, station 2 shows a value ranging from 13.3-19.6 mg / l and station 3 shows a value ranging 11.9- 18.9 mg / l. In general, carbon dioxide at the three stations increases with increasing depth. Changes in carbon dioxide are influenced by increased microbial activity to break down organic matter from metabolic waste or fish feed residue so that carbon dioxide ($CO_2$) increases, and oxygen ($O_2$) decreases [18].

The BOD value of Cirata Reservoir 6.1-7.8 mg / l, Station 1 shows values ranging from 6.4 to 7.7 mg / l, station 2 shows values ranging from 5.2 to 8.3 and station 3 shows values ranging from 7 , 2-8.3 mg / l. Natural waters have a BOD value between 0.5-7.0 mg / l and waters that have a BOD value of more than 10 mg / l are considered to have been polluted [19]. Changes in the BOD value are influenced by river currents that flow swiftly from station 1 to station 2 and accumulate at station 3. This results in organic matter that should have settled below to rise upward and move to station 3. If the BOD is a water the larger, the lower the dissolved oxygen (DO) levels [20].

The DO value of Cirata Reservoir is 6.9-7.3 mg / l, Station 1 shows the DO value shows a value ranging from 5.6-8.8 mg / l, station 2 shows a value ranging from 5.2-8.7 mg / l and station 3 shows values ranging from 6.2 to 8.0 mg / l. The three stations experience changes in DO along with the depth of the waters. This is due to decreased oxygen supply from photosynthesis and diffusion [21]. The decrease in DO in the waters is also caused by a lot of waste input from feed residue, metabolic waste, and human activities around the floating net cage. Dissolved oxygen will decrease if a lot of waste, especially organic waste, enters the water [20]. In addition, the cause of reduced dissolved oxygen in water is due to waste materials that consume oxygen. These materials consist of ingredients that are easily decomposed by bacteria in the presence of oxygen, so that the available oxygen is consumed by the active bacteria to break down these materials [22]

The nitrate value of Cirata Reservoir is 0.208-0.222 mg / l, Station 1 shows a value ranging from 0.197 to 0.223 mg / l, station 2 shows a value ranging from 0.204-0.232 mg / l and station 3 shows a value ranging from 0.192-0.243 mg / l. The feces is a major contributing factor to increasing nitrate[15]. In addition, the low level of nitrates on the surface is due to the fact that it is widely used by phytoplankton for protein synthesis, that plants need nitrogen for protein synthesis [15]. Nitrate is a substance that can be used by algae and aquatic plants to grow and is an indicator that waters are fertile or not [23].

The ammonia value of Cirata Reservoir 0.00283-0.00305mg / l, station 1 shows a scaled value of 0.002-0.003 mg / l, station 2 shows a scaled value of 0.002-0.003 mg / l, and station 3 shows a scaled value of 0.002-0.004 mg / l . The water quality standard is 0.02 mg / l, so it can be categorized as feasible for fish farming activities. High ammonia will be toxic in the waters. The source of the presence of ammonia in waters derived from the results of the decomposition of organic matter and fish metabolism [24].

The phosphate value of Cirata Reservoir is 0.165-0.167 mg / l, Station 1 shows a value ranging from 0.166 to 0.168 mg / l, station 2 shows a value ranging from 0.159 to 0.178 mg / l and station 3 shows a value ranging from 0.164 to 0.168 mg / l. The water quality standard is 0.2 mg / l, so it can be categorized as feasible for fish farming activities. The addition to weathering mineral rocks, phosphate also comes from the decomposition of organic matter [15]. The greater phosphate concentration, the greater industrial and domestic waste content. The phosphate and nitrate are essential for growth and metabolism [25].

## 4. CONCLUSION

The water quality in Cirata Reservoir waters is currently classified as suitable for fish farming activities. The floating net cage at station 1 which is denser than the other stations does not always show the worst water parameters. The pH value ranges from 7.1 to 7.3 mg / l is still classified as appropriate because the quality standard is 6-7, the DO value ranges from 6.9-7.3 mg / l is still considered appropriate because the quality standard is 3-4 mg / l, the COD value is around 15, 4-16.1 mg / l is still classified as appropriate because the quality standard is <50 mg / l, the ammonia value ranges from 0.00283-0.00305 is still quite appropriate because the quality

standard is 0.02 mg / l, the nitrate value ranges from 0.208-0.222 mg / l is still classified as appropriate because the quality standard is 10 mg / l, and the phosphate value ranges from 0.165 to 0.167 mg / l is still classified as appropriate because the quality standard is 0.2 mg / l. In the primary productivity value, station 3 is greater than station 1.Water quality in Cirata Reservoir after being measured is generally in the appropriate category because it does not exceed the water quality standard, but there are several parameters that exceed these quality standards, including temperature, BOD, and $CO_2$.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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