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RESEARCH ARTICLE

DETERMINATION OF WATERS CARRYING CAPACITY FOR SUSTAINABLE AQUACULTURE MANAGEMENT IN JATIGEDE RESERVOIR, WEST JAVA, INDONESIA

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ABSTRACT

Aquaculture in inland water has the potential to lead to the degradation of the aquatic environment, mainly due to the occurrence of eutrophication. The rise in phosphorus levels can be linked to the excretion of fish and the presence of uneaten feed. The aquatic ecosystem possesses the ability to self-purification and cleanse the phosphorus (P) load. Evaluating the carrying capacity of aquatic environments is essential for the adoption of sustainable aquaculture practices. This study aimed to identify the parameters of aquaculture utilizing a double-layer system, serving as a foundation for assessing the ecological carrying capacity of the Jatigede Reservoir waters for aquaculture activities. From March to May 2021, an evaluation of the aquaculture experiment in Jatiluhur Reservoir was conducted using a double-layer floating net cage (FNC) technique. The fish reared using the double-layer system consisted of common carp in the upper layer and tilapia in the bottom layer. In March, June, and September of 2021, monitoring of water quality parameters in the Jatigede Reservoir was conducted, focusing on total phosphorus, water temperature, pH, and dissolved oxygen. The hydro morphological parameters of the Jatigede Reservoir, specifically area, volume, and water discharge, were analyzed using data from 2018-2020. The weights of the common carp and nile tilapia seeds produced were 13.5 g and 49.0 g, respectively, resulting in total weights of 150 kg and 200 kg. The findings of the study indicated that the FCR value in the double-layer FNC system was 1.61, along with a P load of 18.1 kg P/ton of harvested fish. The findings suggested that the integration of a double layer of FNC might had the potential to enhance the FCR value from 1.71 to 1.61. The utilization of 2,600 kg of feed led to yields of 1,650 kg for common carp and 316 kg for Nile tilapia. The ecological carrying capacity of the double-layer FNC activities in Jatigede Reservoir was measured at 7,207 tons per year, indicating a 22% increase from the single-layer FNC capacity, which stood at 5,482 tons per year.

KEYWORDS

Phosphorus load, Common carp, Nile tilapia, Jatigede Reservoir

1. INTRODUCTION

Aquaculture plays a crucial role in preventing malnutrition, maintaining food security, and reducing poverty (Rana et al., 2022; Kallem and Sabi, 2021; Muhala et al., 2021). Environmental degradation resulting from phosphorus pollution from aquaculture will impede the sustainability of these practices (Fialho et al., 2021; Moura et al., 2016). Environmental degradation at aquaculture sites leads to reduced production and often results in mass fish deaths (Opiyo et al., 2018). Elevated production levels without the oversight of substantial nutrient inputs will lead to eutrophication (Schindler, 2017; Venturoti et al., 2015), as observed in aquaculture practices in Lake Toba (Hutajulu and Harahap, 2023). Strategies to mitigate the discharge of nitrogen and phosphorus pollutants should align with the environmental purification capacity (Pulkkinen et al., 2021). Uneaten feed contributes nitrogen and phosphorus from aquaculture activities to aquatic environments, emphasizing the need to regulate aquaculture production (Cacho et al., 2020). Key factors for sustainable aquaculture practices include water-carrying capacity and resources (Hu et al., 2023; David et al., 2015). This related to determining a maximum sustainable yield, mitigating environmental degradation and the over-exploitation of natural resources, as well as various applications of aquatic ecosystems (Lewandowski et al., 2021; Zhang et al., 2022). The Jatigede reservoir plays multiple functions, including providing drinking water, generating hydroelectric power, and facilitating tourism.

The environmental impact of aquaculture is influenced by factors such as production levels, the species of fish concerned, and the composition of the feed utilized (Borromeo et al., 2022). Environmental impact assessment and risk management serve as essential strategies for planning the management of aquaculture activities, taking into account the physical-chemical aspects of water and the biology of fish (El-Otify, 2015). The unregulated and spontaneous expansion of aquaculture practices is likely to lead to environmental damage and disruption in society (Csavas, 1995). Aquaculture activities using floating net cages in the Jatigede Reservoir are currently restricted by the regional regulations of Sumedang Regency. Similar occurrences were noted in Lake Victoria, Tanzania, attributed to worries regarding environmental degradation (Kashindye et al., 2015).

The implementation of aquaculture practices utilizing floating net cages in Indonesia predominantly occurs in lakes and reservoirs. In 2020, floating net cage aquaculture accounted for approximately 20% of inland water fish farm production (FAO, 2022). The establishment of aquaculture in floating net cages within aquatic environments should align with the carrying capacity to ensure sustainability (Junaidi et al., 2022). Activities

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related to aquaculture in reservoir or lake waters should take into account the viability of water quality and the carrying capacity of these aquatic environments (Phan et al., 2021). Polluted water will restrict the development and quality of the fish being cultivated (Manalo and Hemavathy, 2023). The use of floating net cages for aquaculture in the Jatigede Reservoir constitutes illegal activities that violate regional regulations, raising concerns about potential environmental degradation (Marsela et al., 2023). Consequently, it is essential to assess the carrying capacity of aquatic environments to ensure the sustainability of cultivated fish production. The assessment of the carrying capacity for aquaculture operations in Indonesia's reservoir and lake waters continues to rely on the parameters of single-layer FNC with a focus on a single species of reared fish (Warningsih et al., 2016; Simanjuntak and Muhammad, 2018; Tribhuwana et al., 2021). This paper aims to assess the water-carrying capacity of the Jatigede reservoir concerning the activities associated with double-layer floating net cages (FNCs). This study aims to maintain the water quality in the Jatigede Reservoir while ensuring that aquaculture by FNC remains sustainable, all without interfering with the other functions of the reservoir construction.

2. Material And Method

2.1 Study Area

The study involved two main activities: experimental research and field research. The experimental research utilizing the double-layer FNC took place in Jatiluhur Reservoir, while the field research was carried out in Jatigede Reservoir, which was considered as a potential site for FNC activities (Figure 1).

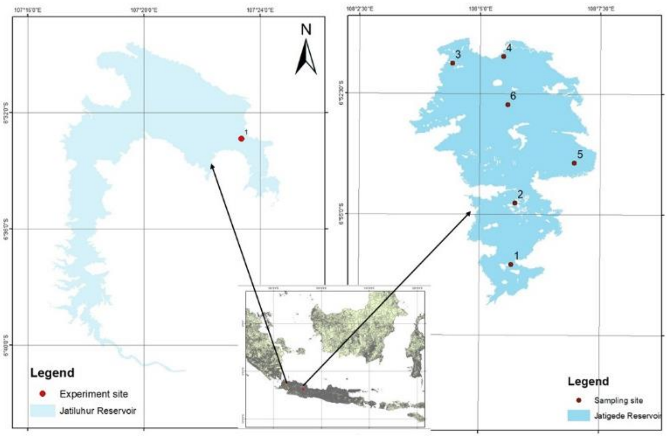


Figure 1: Map of research site

2.1.1 Experimental Research of Double-layer FNC

The experimental research of double-layer FNC was implemented in the Jatiluhur Reservoir, Purwakarta Regency, West Java, Indonesia from March to May 2021, to obtain values for aquaculture parameters, specifically Feed Conversion Ratio (FCR), harvest yields, and feed amounts. The aquaculture parameters would play a crucial role in assessing the waste load produced by aquaculture activities, which was essential for calculating the carrying capacity of the waters in the Jatigede Reservoir. The detailed construction of double FNC was outlined in (Figure 2) (Astuti et al., 2023).

The pollution load resulting from aquaculture activities was determined by the feed conversion ratio (FCR), the phosphorus concentration in the feed, and the phosphorus retention in the fish body (Beveridge, 2004). The parameters for aquaculture carrying capacity have been established through experimental methods involving a double-layer FNC. The double-layer FNC comprised two cages FNC: the upper layer, which was designed as two cages measuring 7x7 m and a depth of 3 m, and the bottom layer, which was designed as a single cage measuring 7x14 m with a depth of 7 m. The upper cage was designated for the rearing of common carp *(Cyprinus carpio)*, whereas the bottom layer was intended for the rearing of Nile tilapia *(Oreochromis niloticus)*. The average weight of common carp seeds maintained was 13.5 g, a total of 75 kg for each cage, while Nile tilapia seeds had an average weight of 49.0 g, amounting to 200 kg. Common carp were fed three times a day, ensuring they received as much food as they could consume. Nile tilapia exclusively consumed the uneaten feed that was discarded from the process of raising common carp. The quantity of feed administered during rearing was documented. The composition of the feed included 27-29% protein, with both ash and water each constituting 11%. After the rearing period, the total weight of all harvested fish was recorded to assess biomass. The analysis of phosphorus content in feed and fish was conducted using the AOAC method. 986.24 (50.1.12.2005). Insitu observations of dissolved oxygen concentration, pH, and water temperature were conducted in double-layer FNC utilizing the Horiba U50 water quality checker. Vertical observations were conducted until a depth of 7 m in double-layer FNC, utilizing one-meter intervals. This observation aimed to provide comparative data regarding the site of aquaculture development utilizing a double-layer FNC in the Jatigede Reservoir.

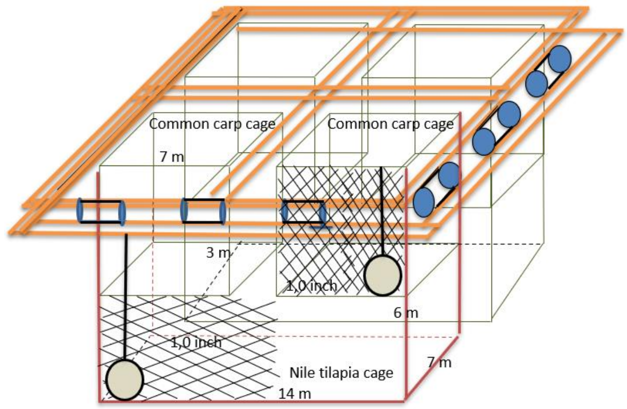


Figure 2: Double-layer floating net cage system

2.1.2 Field Research for Determination of Carrying Capacity

Water quality observations, specifically focusing on total phosphorus, water temperature, and dissolved oxygen in the Jatigede Reservoir, Sumedang Regency, West Java, Indonesia were conducted in March, June, and September 2021 at six observation sites (Figure 1). Water sampling for total phosphorus (P) observations was conducted at the surface and a depth of 4 m. The total phosphorus in water samples was analyzed using the ascorbic acid method (APHA, 2017). The analysis of total phosphorus in the Jatigede reservoir aimed to establish the phosphorus concentration before the initiation of aquaculture activities and to assess the permissible phosphorus waste levels for the aquatic environment. Measurements of dissolved oxygen concentration, pH, and water temperature were conducted vertically until to a depth of 9.0 m with an interval of one meter in the Jatigede Reservoir in situ utilizing the Horiba U50 water quality checker. This observation aims to assess the suitability of the site for aquaculture practice. The hydro morphometric data for the Jatigede Reservoir, which includes volume, area, and water discharge from the reservoir, were obtained from the Jatigede Dam Management Unit.

2.2 Data Analysis

The feed conversion ratio (FCR) value was calculated based on the equation from Berzi-Nagy et al. (2021) as follows.

$$FCR = \frac{Feed\ input\ (kg)}{Weight\ gain\ (kg)}$$

The determination of phosphorus impact on the environment (Penv) resulting from intensive farming practices was derived from the FCR value, along with the phosphorus concentrations in feed [P]feed and in fish [P]fish (Beveridge, 1984; Beveridge, 2004):

$$P_{env} = \left(FCRxP_{feed}\right) - P_{fish}$$

The balance of phosphorus serves as a fundamental criterion for assessing the ecological carrying capacity related to aquaculture practices (Dillon and Rigler, 1975). This method has been employed to determine the ecological carrying capacity for aquaculture activities in lakes or reservoirs, as outlined by Beveridge (2004), following these specific steps:

1. The carrying capacity of reservoir waters for intensive aquaculture activities was determined by the difference in phosphorus concentration △[P, mg/m3] between the acceptable environmental phosphorus level from aquaculture activities [P]f and the measured phosphorus level in the reservoir [P]i.

$$\triangle\,[\mathrm{P}] = [\mathrm{P}]_{\mathrm{f}} - [\mathrm{P}]_{\mathrm{i}}$$

2. △P was associated with the P load resulting from intensive aquaculture practices utilizing floating net cages (Lfish, kgP/ton of fish harvest), the area of the reservoir (A, m2), and the flushing rate (ρ, per year).

$$\triangle\,\mathrm{P} = \mathrm{L_{fish}}(1 - \mathrm{R_{fish}})\bar{\mathrm{z}}\rho$$

3. The average depth ($\bar{z}$, m) of the reservoir was determined by the volume (V, m3) and the area of the reservoir (A, m2).

$$\bar{z} = \frac{V}{A}$$

4. The flushing rate (ρ, per year) of the reservoir was connected to the outflow of water (Q, m3/year) and the volume of the reservoir (V, m3).

$$\rho = Q_o/V$$

5. Rfish was determined by the value of the proportion of P that permanently settles into the sediment due to solids deposition (x) and the retention coefficient (R) of phosphorus.

$$R_{fish} = x + [1 - x]R$$

6. The calculation of the phosphorus retention coefficient was derived from the parameters of the flushing rate.

$$R = \frac{1}{(1 + 0.515\rho^{0.551})}$$

7. P load from aquaculture activities that could be accepted by the reservoir environment (La)

$$L_a = L_{fish} x A$$

8. Carrying capacity (CC) of reservoirs for intensive aquaculture production (tons/year)

$$CC = \frac{L_a}{P_{env}}$$

3. Results

The parameters and results from the experiments on common carp and Nile tilapia cultivation utilizing double-layer FNC are detailed in Table 1. The yield of common carp and Nile tilapia reached 1,650 kg and 316 kg, respectively, with a total feed input of 2,600 kg. The FCR value with the double-layer FNC was measured at 1.61. The duration for one production cycle was 75 days. The FCR value obtained for common carp reared using a single-layer FNC was 1.73. The implementation of double-layer FNC in Nile tilapia rearing has been shown to enhance the FCR value by 7.12%. This occurs as Nile tilapia raised in the bottom layer make use of the feed that was discarded from common carp cultivation. The increase in the weight of reared Nile tilapia demonstrated their effective used of wasted feed.

Table 1: Parameters in the double-layer FNC experiment

Parameters	Units	Value
1. Number of seeds		
Common carp	kg	150
Nile tilapia	kg	200
2. Size of seeds		
Common carp	g	13.5
Nile tilapia	g	49.0
3. Time of rearing	days	75
4. Number of feeds	kg	2,600
5. Averages of harvest size		
Common carp	g	248
Nile tilapia	g	202
6. Yield biomass		
Common carp	kg	1,650
Nile tilapia	kg	316
7. FCR		1.61
8. Phosphorus content		
Feed	%	1.53
Common carp	%	0.46
Nile tilapia	%	0.37

The implementation of double-layer FNC was anticipated to minimize the feed that was lost into the waters. This would influence the reduction of phosphorus load in the waters, contributing to a more environmentally sustainable condition. The reduction in phosphorus load from this cultivation activity could also be attributed to the enhancement of the FCR value. The feed that would otherwise be wasted in the environment could be effectively utilized by Nile tilapia.

The hydro morphological data of the Jatigede reservoir spans three years and includes metrics such as volume, outflow, reservoir area, average depth, and flushing rate (Figure 3). In the years 2018, 2019, and 2020, the volume of the Jatigede reservoir was recorded at 290.6-710.1 million m^3, 271-753.1 million m^3, and 332.2-956.1 million m^3, respectively. The Jatigede reservoir area for the years 2018, 2019, and 2020 varied between 1,910-3,325 ha; 1,814-3,432 ha; and 2,108-3,897 ha; respectively. The peak volume and area in Jatigede Reservoir were observed from January to July annually. During that period, the volume and area of the Jatigede reservoir ranged from 494.2 to 956.1 million m^3 and from 2,754.6 to 3,897 ha, respectively. The water outflow of Jatigede Reservoir for the years 2018, 2019, and 2020 was recorded at 92.7-3,325; 66.7-5,858; and 2,018-3,897 million m^3, respectively. The peak water outflow for the years 2018, 2019, and 2020 was recorded during the periods of February to May, March to June, and April to August, with values of 2,973.6 to 4,991.7; 2,103.5 to 5,858.7; and 2,453.6 to 3,496.7 million m^3, respectively.

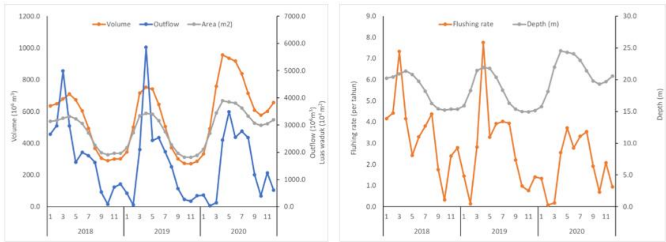
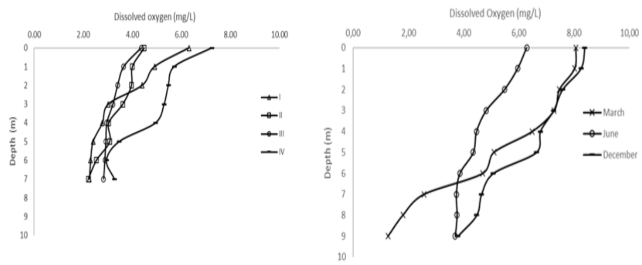
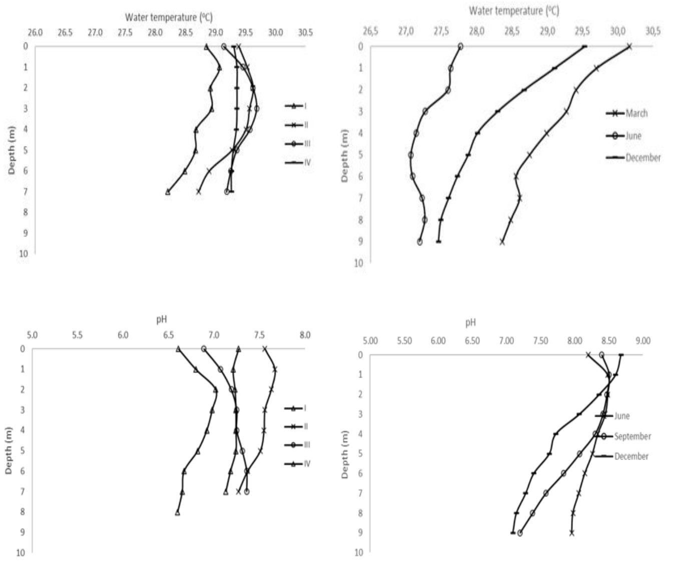


Figure 3: Jatigede Reservoir's hydro morphometry from 2018–2020

The flushing rates of the Jatigede reservoir for the years 2018, 2019, and 2020 were recorded at ranges of 0.3-7.13, 0.1-7.8, and 0.1-3.7 per year, respectively. The peak flushing rate in 2018 was observed during February-March, ranging from 4.2 to 7.3 per year. In contrast, the years 2019 and 2020 observed the highest rates from April to August, with values of 3.7 to 7.8 and 2.6 to 3.7 per year, respectively. The Jatigede reservoir exhibited a depth ranging from 15 to 24.5 m from 2018 to 2020, with the maximum depth recorded between January and July each year. During those months, the depth of the Jatigede Reservoir in 2018, 2019, and 2020 varied between 19.7-21.4 m, 18.3-21.9 m, and 22-24.5 m, respectively.

The vertical profile of dissolved oxygen, pH, and water temperature were measured to a depth of 10 meters, utilizing one-meter intervals (Figure 4). This assessment aimed to evaluate the viability of the aquaculture site by examining factors such as depth, oxygen concentration, and water temperature. Measurements were conducted in two water bodies: the Jatiluhur Reservoir, designated as the experimental site, and the Jatigede Reservoir, identified as a potential aquaculture site. The profiles of dissolved oxygen, water temperature, and pH for both locations was illustrated in Figure 4. The reduction in dissolved oxygen levels was observed as the depth of the measurement increased. The concentration of dissolved oxygen at a depth of 0-3 m, corresponding to the upper layer FNC, varied from 2.81 to 9.06 mg/L, with an average of 7.09 mg/L. In contrast, at a depth of 4-7 m, representing the bottom layer, the concentration ranged from 3.03 to 8.66 mg/L, averaging 5.84 mg/L. At a depth of 8-10 m, the concentration of dissolved oxygen varied between 0.26 and 5.86 mg/L, with an average value of 1.43 mg/L. The levels of dissolved oxygen at the Jatiluhur Reservoir double-layer FNC experimental site at a depth of 0-3 m varied between 3.02-7.2 mg/L, with an average of 4.56 mg/L. At a depth of 4-7 m, the range was 2.21-4.95 mg/L, averaging 2.93 mg/L.



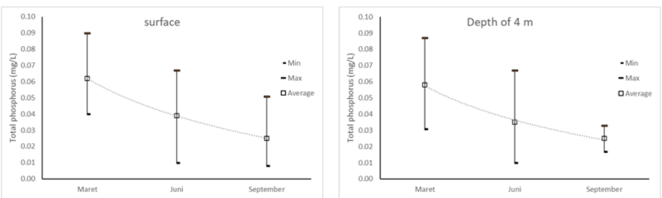


(a) Jatiluhur Reservoir (b) Jatigede Reservoir

Figure 4: Dissolved oxygen, water temperature, and pH profiles in (a) Jatiluhur Reservoir and (b) Jatigede Reservoir

The water temperature in Jatigede Reservoir at a depth of 0 - 3 meters varied between 26.8 and 30.9°C, with an average of 28.77°C. At a depth of 4 - 7 meters, the temperature ranged from 26.3 to 29.3°C, averaging 27.94°C. For depths of 8 - 10 meters, the temperature ranged from 27.0 to 30.4°C, with an average of 27.77°C. The water temperature in Jatigede Reservoir showed a decline as depth increased. In Jatiluhur Reservoir, similar observations were made regarding water temperature. At a depth of 0-3 m, the temperature ranged from 28.85 to 29.69 °C, while at a depth of 4-8 m, it ranged from 28.21 to 29.58 °C, with averages noted for both depths. The pH levels in Jatigede Reservoir varied at different depths: at 0-3 meters, the range was 6.8-9.12 with an average of 8.40; at 4-7 meters, the range was 7.04-8.62 with an average of 7.90; and at 8-10 meters, the range was 6.75-8.45 with an average of 7.88. The pH levels at the double-layer FNC experimental site was measured at a depth of 0-3 m, showing values between 6.61 and 7.67, with an average of 7.20. At a depth of 4-7 m, the pH ranged from 6.65 to 7.55, resulting in an average of 7.80. The concentrations of dissolved oxygen, water temperature, and pH in the Jatigede Reservoir, a potential aquaculture site, were found to be nearly identical to those in the Jatiluhur Reservoir. Analysis of water quality parameters, specifically dissolved oxygen, water temperature, and pH, indicated that the double-layer FNC was applicable in the Jatigede Reservoir.

The total phosphorus concentration at the surface was generally higher than that at a depth of 4 m. The phosphorus concentration at the surface varied between 0.008 to 0.09 mg/L, yielding an average of 0.043 mg/L. At a depth of four meters, the concentration ranged from 0.01 to 0.087 mg/L, with an average of 0.039 mg/L. The peak total phosphorus concentration was observed in March, both at the surface and at a depth of four meters, followed by a decline in June and December (Figure 5).



(a) (b)

Figure 5: Total P concentration in Jatigede Reservoir (a) surface and (b) Depth of 4 m

The phosphorus concentration in the Jatigede Reservoir remained compliant with the class II quality criteria established by the Republic of Indonesia Presidential Regulation No. 22 of 2021 recorded at 0.1 mg/L. Class II quality criteria may be applicable to aquaculture practices, animal husbandry practices, crop irrigation practices, and other essential requirements. The findings indicated that the Jatigede Reservoir's waters remain capable of accommodating phosphorus loads from various activities, including aquaculture, without disrupting other uses. The parameters utilized to assess the carrying capacity of water for aquaculture activities in the Jatigede Reservoir are detailed in Table 2. The value represented the mean observed during the period from 2018 to 2020.

Table 2: Parameters utilized in the calculation of carrying capacity

Parameters	Unit	Value
Morphometrics, hydrology, and phosphorus budget		
- Surface area	km²	28.28
- Lake volume	x10⁶ m³	558.5
- Mean depth	m	19.1
- Total outflow	x10⁶ m³	1647.6
- Flushing rate	per year	2.7
- Phosphorus retention coefficient		0.45
Characteristics of cage-fish aquaculture		
- Phosphorus content in feed	%	1.53
- Feed conversion ratio		1.61
- Mean P fish retention		
Common carp	%	0.59
Nile tilapia	%	0.46

The phosphorus concentration in the feed utilized in aquaculture within double-layer FNC was measured at 1.53%. The phosphorus concentration in common carp and Nile tilapia was measured at 0.59% and 0.46%, respectively. The phosphorus content for each ton of feed was 15.6 kg, with common carp and Nile tilapia contributing 5.9 kg and 4.6 kg, respectively. The phosphorus pollution load to the environment resulting from double-layer FNC practice was measured at 16.5 kg P per ton of harvested fish. In fish aquaculture utilizing a single-layer FNC, the phosphorus load released into the environment amounted to 21.8 kg per ton of harvested fish. The implementation of double-layer FNC in aquaculture activities has the potential to decrease the phosphorus load released into the environment by 3.72 kg per ton of harvested fish, equating to a reduction of 24.3%. The phosphorus load released into the waters with double-layer FNC was 18.1 kg P per ton of harvested fish. The capacity for intensive aquaculture practice in the Jatigede Reservoir utilizing double-layer FNC was determined to be 7,207 tons per year. Implementing double-layer FNC could enhanced production by 22.0% in comparison to single-layer FNC, which amounted to 5,482 tons per year. The implementation of double-layer FNC would enhanced the water's carrying capacity due to the reduced P load that was released into the environment.

4. Discussion

The long-term monitoring of the effects of aquaculture practices in lakes and reservoirs is crucial for ensuring the sustainability of these activities (Hu et al., 2022). The feed's quality and quantity provided will influence fish production and the level of pollutants produced (El-Hack et al., 2022). Aquaculture activities can lead to alterations in water quality and plankton communities in the areas where these activities are conducted (Sari et al., 2024; Kashindye et al., 2015; Lazard et al., 2010). Eutrophication represents a negative impact of aquaculture practices, resulting from elevated nitrogen and phosphorus nutrient loads (Sasi et al., 2017; Karakassis et al., 2005). The source of P in aquaculture activities is the feed utilized during the rearing process (Kurniawan et al., 2021). The quality of feed is a critical factor influencing the production and sustainability of aquaculture practices in aquatic environments (Afrianto et al., 2024). The excessive levels of phosphorus resulting from aquaculture activities lead to eutrophication, as observed in the Cirata Reservoir (Pratiwi et al., 2020). The excretion of phosphorus from reared fish varies between 69-86% of the feed input, a range that is affected by factors such as genetics, life stage, size, and the maintenance system in place (Lazzari and Baldisserotto, 2008).

The deterioration of water quality in reservoirs and lakes subjected to intensive aquaculture is attributed to fish production surpassing the waters' carrying capacity (Tribhuwana et al., 2021). Environmental management stands as a crucial focus for sustainable aquaculture practices (Witus and Vun, 2016). The influence of leftover feed and waste from FNC is contingent upon the production associated with feed that is only partially ingested and utilized (Osei et al., 2018). The slow water flow observed at aquaculture sites in reservoirs and lakes necessitates a thorough investigation into the impact of intensive aquaculture on water eutrophication (Guo et al., 2009). The phosphorus nutrient waste generated serves as a significant environmental indicator for cultured fish production (Moraes et al., 2015). Consequently, it is essential to manage aquaculture activities effectively to mitigate the negative impacts of waste loads (El-Gayar et al., 2023). One of the key parameters indicating the impact of aquaculture activities is total phosphorus (Osei et al., 2019). Strategies for managing aquaculture activities in floating net cages involve assessing the carrying capacity (White, 2021).

The FCR value of aquaculture activities is influenced by water quality parameters including dissolved oxygen concentration, temperature, and pH (Mengistu et al., 2020). The ideal water temperature for Nile tilapia maintenance is between 27-32 oC, with pH levels ranging from 6-9 and dissolved oxygen exceeding 5.0 mg/L (Kumar et al., 2023; Idam and Elsheakh, 2022). Common carp can withstand water temperatures ranging from 25 to 32 degrees Celsius, with an ideal pH level for growth between 6.5 and 9.0, and a minimum dissolved oxygen concentration of 5 mg/L (Yanuhar et al., 2022; Goran et al., 2016). Analysis of various water quality parameters, including pH, water temperature, and dissolved oxygen in the Jatigede Reservoir, indicates that conditions are suitable for the cultivation of common carp and Nile tilapia. The implementation of common carp and Nile tilapia cultivation using double-layer floating net cages is feasible in the waters of the Jatigede Reservoir.

The quantity of seeds (kg/plot) for common carp (20-200) and Nile tilapia (20-150) spread using this double-layer FNC is greater, accompanied by a lower FCR value (1.69) compared to the aquaculture practices in Cirata Reservoir (Ardi, 2013). The P load to the aquatic environment using this double-layer FNC is reduced in comparison to common carp rearing in Lake Maninjau with a single-layer FNC, which is approximately 17.44-18.85 kg/ton of fish production (Syandri et al., 2018; Syandri et al., 2017). The reduced phosphorus load is anticipated to maintain water quality at the aquaculture site, ensuring the sustainability of aquaculture activities (Putri et al., 2019). The Jatigede reservoir has a higher carrying capacity for aquaculture activities compared to the Wadaslintang reservoir in Indonesia, which is 4,179 tons per year and the Kesikkopru reservoir in Turkey, which stands at 3,335 tons per year (Pulatsu, 2003; Widyastuti et al., 2009). The reason for this is that Wadaslintang Reservoir in Indonesia and Kesikkopru Reservoir in Turkey have smaller areas compared to Jatigede Reservoir, which includes 1,460 ha and 650 ha respectively. Furthermore, Wadaslintang Reservoir in Indonesia exhibits a lower flushing rate, while Kesikkopru Reservoir in Turkey has a smaller volume compared to Jatigede Reservoir.

Determining the carrying capacity of aquatic environments is crucial for effectively managing reservoirs utilized in aquaculture practices. This aims to mitigate the deterioration of aquatic ecosystems caused by rising nitrogen and phosphorus pollution levels caused by aquaculture practices. Therefore, aquaculture practices can be conducted sustainably and do not conflict with various other uses.

5. Conclusion

Based on water quality parameters show that Jatigede Reservoir is suitable for the development of floating net cages (FNC) with a double-layer system. The Jatigede Reservoir has a carrying capacity for aquaculture activities utilizing double-layer FNC, amounting to 7,207 tonnes per year, which is equivalent to 3,660 double-layer FNC units. The implementation of double-layer FNC contributes positively to environmental sustainability by decreasing the phosphorus load to the environment by 16.5 kg P per tonne of harvested fish, alongside a reduced FCR value. The implementation of double-layer FNCs has the potential to enhance the carrying capacity of the waters by 22.0% in comparison to single-layer FNCs. The implementation of double FNC has the potential to enhance fish production while being environmentally sustainable, meaning that aquaculture practices could possibly achieve sustainability over the long term. This eco-friendly floating net cage is expected to maintain water quality for various other uses

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Conflicts Of Interest

Authors declare no conflict of interest The authors contributed as the primary contributor to this paper. All authors read and approved the final paper.

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