GSJ: Volume 8, Issue 7, July 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

EVALUATION OF THE CARRYING CAPACITY OF THE DARMA RESERVOIR FOR FLOATING NET CAGES IN KUNINGAN DISTRICT, WEST JAVA

Vera Anggraeni Dewi[1*], Zahidah Hasan[2] , Iis Rostini[2], and Heti Herawati[2]
[1]Student of Fisheries, Faculty of Fisheries and Marine Science, Padjadjaran University, Indonesia
[2]Lecture of Fisheries, Faculty of Fisheries and Marine Science, Padjadjaran University, Indonesia
*E-mail address: veraanggraenidewi@gmail.com

ABSTRACT

This research aims to determine the carrying capacity of Darma Reservoir waters for the utilization of the floating net cages aquaculture. The research was conducted on December 16, 2019 to January 6, 2020. Method used in this research was survey with comparative descriptive data analysis. Water samples were taken as many as four times at four research sites in the waters. Water quality parameters measured were temperature, light transparency, pH, CO_2, BOD_5, DO, NH_3 and total phosphorus. Analysis of the carrying capacity of waters is determined through the total phosphorus approach. Based on the results of this research it can be concluded that the number of floating net cages aquaculture system in the Darma Reservoir has exceeded the reservoir's carrying capacity. Feed waste from fish farming contributes to 234,507.2 kg / year (17.6 µg/l/day) of pollution load waste. The decrease of water quality is caused by an abundance of feed waste (155,459.8 kg P / year) and metabolic or faecal residues (79,047.4 kg P / year). The number of floating net cages in the Darma Reservoir has exceeded the reservoir capacity by 10,456 bags which should only be allowed as many as 3,068 bags floating net cages.

Keywords: *Carrying Capacity, Darma Reservoir, Floating Net Cages, Water Quality*

1. INTRODUCTION

Darma Reservoir is an irrigation reservoir located in Kuningan District, West Java. Most of the people living around the Darma Reservoir do aquaculture in the floating net cages system. Aquaculture in floating net cages provide economic benefits because it provide regular income to the community. The presence of floating net cages in the Darma Reservoir is currently 2,614 units or 10,456 bags with 211 people ownership [1].

Utilization of reservoirs and lakes for floating net cages aquaculture system activities, every year is always faced with a number of problems including the occurrence of mass death of fish as occured in the Darma Reservoir. The mass deaths of tens of tons of fish in floating net cages in the Darma Reservoir occurred in a row starting Saturday night, November 10, 2018 until Sunday morning, November 11, 2018. This time the mass death of fish occurred to all floating net cages blocks scattered in the Darma Reservoir, spesifically in the floating net cages blocks around Jagara, Darma, Cipasung, and Paninggaran Villages [2]

One of the main components of fish culture management is identification and calculation of carrying capacity water resources [3]. Carrying capacity is a population of aquatic organisms that will be supported by an area or volume of water that is determined without decreasing quality [4]. Determination of carrying capacity must be considered so that the utilization and management of fisheries resources in the waters can be sustainable. The purpose of this study was to determine the carrying capacity of Darma Reservoir waters for the utilization of the floating net cages aquaculture activities.

2. METHODOLOGY

2.1 Study Area

© GSJ

The research was conducted on December 16, 2019 to January 6, 2020. Observation and sampling stations (Figure 1) were carried out using the purposive sampling method which was divided into four stations. The observation station for sampling is chosen based on organic material input, including

Station 1 : Located at the reservoir inlet
Station 2 : Located in the middle of the body of the Darma Reservoir with the highest number of floating net cages
Station 3 : Located in the middle of the body of the Darma Reservoir with the lowest number of floating net cages
Station 4 : Located at the reservoir outlet

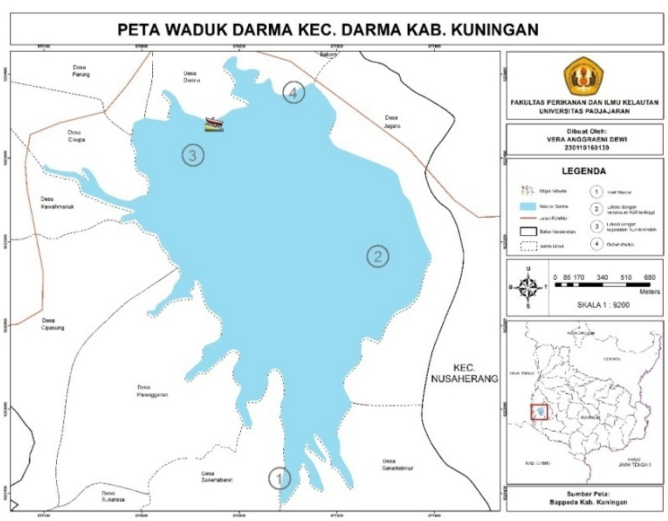

Figure 1. Map of Darma Reservoir and study area

2.2 Sampling and Measurement

Water sampling were carried out with a seven-day period of four times samplings. Water quality parameters measured were temperature, light transparency, pH, CO_2, BOD_5, DO, NH_3 and total phosphorus. Measurements of temperature, light transparency, pH, CO_2 and DO are done in situ (directly in study area), while measurements of BOD_5, NH_3 and total phosphorus are carried out ex situ in the laboratory. Carrying capacity is determined through an organic load approach such as total phosphorus in waters.

2.3 Data Analysis

Method used in this research was survey with comparative descriptive data analysis that compares the values of water quality parameters with water quality standards class II in Government Regulation No. 82, 2001 [5]. Analysis of carrying capacity is calculated based on the Minister of Environment Regulation No. 28/2009.

2.3.1 Carrying Capacity of Darma Reservoir

Carrying capacity for floating net cages calculation steps are as follows:

1. Morphology and Hydrology of Reservoir

$$Z = V / A \quad (1)$$

$$\rho = Q / V \quad (2)$$

Explanation:

Z : Average depth of reservoir (m)
V : Volume of reservoir (million m^3)
A : Area of reservoir (Ha)
ρ : Rate of water change of reservoir (per year)
Q : Number of discharge water reservoirs out (million m^3 /year)

2. Phosphorus Pollution Load Allocation (P)

$$\Delta[P] = [P]f - [P]i \quad (3)$$

Explanation:

Δ [P] : Total phosphorus allocation of fish farming (mg/m^3)
[P]f : The maximum P concentration that can be accepted by water bodies (mg/m^3), For common carp and tilapia 250 mg/m^3
[P]i : Total phosphorus parameters of monitoring results of reservoirs (mg/m^3)

3. Total Phosphorus Pollution Load

$$L_{fish} = \Delta[P]\, Z\, \rho / (1 - Rfish) \quad (4)$$

$$R_{fish} = (1 - x)*R + x \quad (5)$$

$$R = 1 \div 1 + 0{,}515\ \rho^{0{,}551} \quad (6)$$

$$La^{fish} = Lfish * A \quad (7)$$

Explanation:

L_{fish} : Total phosphorus fish waste capacity per unit of reservoir area (g P/m^3)
La : Total capacity of Total phosphorus fish waste in lake waters (g P/year)

R : Total phosphorus left with sediment (mg P/m^3)
R_{fish} : The proportion of total phosphorus that dissolves into the sediment after the cage is present (mg P)
X : Proportion of Total phosphorus that is permanently entered into the base, 45 - 50%

4. Feed and Waste Phosphorus Aquaculture Net Cage

$$PLP = FCR \times P_{feed} - P_{fish} \quad (8)$$

Explanation:
P_{LP} : Total phosphorus entering the reservoir from the fish waste (kg P/ton of fish)
FCR : Feed Convertion Ratio (ton/ton feed fish)
P_{feed} : Total phosphorus Levels in the feed (kg/ton feed)
P_{fish} : Total–P Levels in fish (kg/ton of fish)

5. Number of Aquaculture

$$LI = La / PLP \quad (9)$$
$$LP = LI \times FCR \quad (10)$$

Explanation:
LI : Total production of net cage culture (tons of fish/year)
LP : Total feed of net cage culture (ton of feed/year)

6. Determination of Net Cage

The Ideal number of cages = LI / Total fish production per year on net cages (11)
Number of cages to be reduced = Total number of existing net cages – The ideal number of cages (12)

3. RESULT AND DISCUSSION

3.1 Temperatur

Based on the measurement results of water quality parameters, the average temperature of the Darma Reservoir waters ranges from 25.0 ± 0.62-25.7 ± 0.76 ^oC (Figure 2). This value is still in the range of temperature are appropriate for fish life. The temperature are appropriate for fish life in the tropics ranges between 25-32^0C [6]. The difference in average temperature at each research station, it is caused by temperature measurement, the longer temperature measurement then the temperature will increase. Relatively low temperatures were obtained from sample measurements in the morning. While high temperatures are obtained in the measurement of water samples in the afternoon until late afternoon [7]

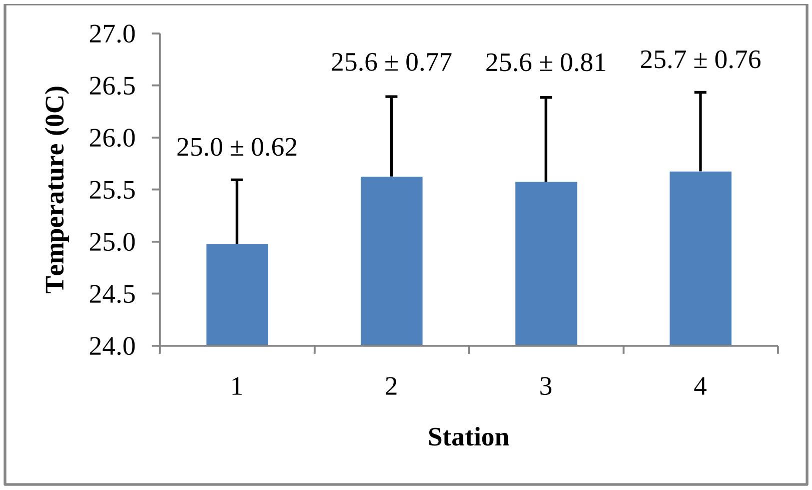

Figure 2. The temperature graphs in waters during research

3.2 Light Transparency

Based on research data, it can be seen that the average of light transparency 0.51 ± 0.04-0.59 ± 0.06 m, the value is still in a good range for fish farming (Figure 3). The light transparency of fish culture waters is less than optimum ranging from 30-40 cm [8]. Station 1 has the highest average of light transparency, it is the location of the entry of water (*inlet*). While station 2 has the lowest average of light transparency, it is the location with the highest number of floating net cages, so that sedimentation is high due to deposition of wasted feed and fish faeces. The value of light transparency in waters is strongly influenced by the presence of weather, turbidity of suspended and dissolved solids (mud and fine sand) [9].

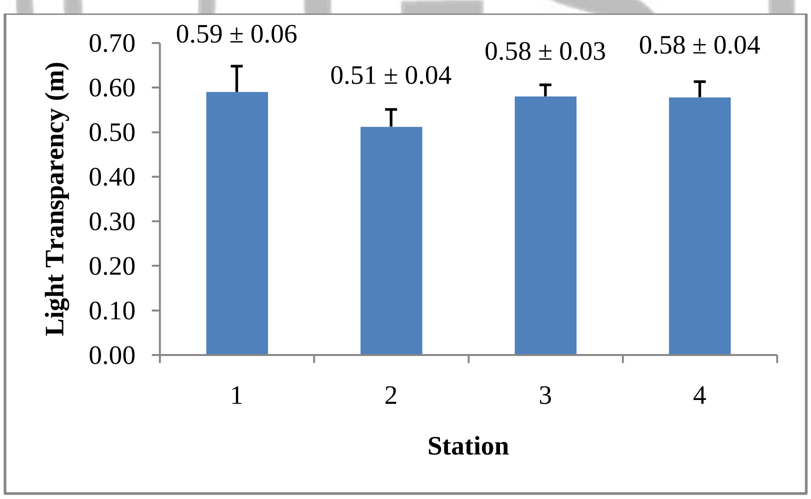

Figure 3. The light transparency graphs in waters during research

3.3 pH

The average pH of the waters of the Darma Reservoir is around 7.2 ± 0.13-7.4 ± 0.11 (Figure 4). The pH is still within the quality standard limits for fish farming according to Government Regulation No. 82, 2001, that is 6-9 [5]. High or low pH values of water depend on several factors, namely, the condition of gases in water such as CO_2, concentrations of carbonate and bicarbonate salts, and the process of decomposition of organic matter at the bottom of the waters [9].

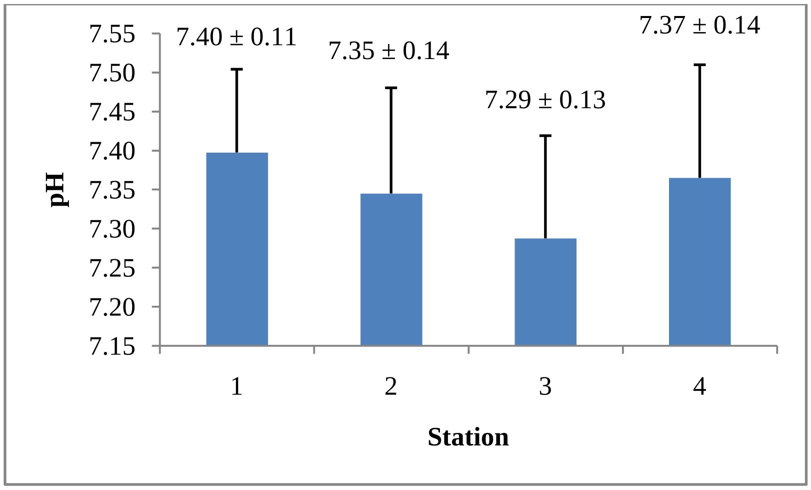

Figure 4. The pH graphs in waters during research

3.4 Carbon dioxide

The average concentration of carbon dioxide in the waters of the Darma Reservoir is around 10.56-15.84 mg/l (Figure 5). The carbon dioxide concentration has passed the threshold intended for the interests of fisheries, but can still be tolerated by aquatic organisms if accompanied by an adequate concentration of dissolved oxygen. Free carbon dioxide concentrations of 10 mg/l can still be tolerated by aquatic organisms, provided they are accompanied by sufficient oxygen concentration [9].

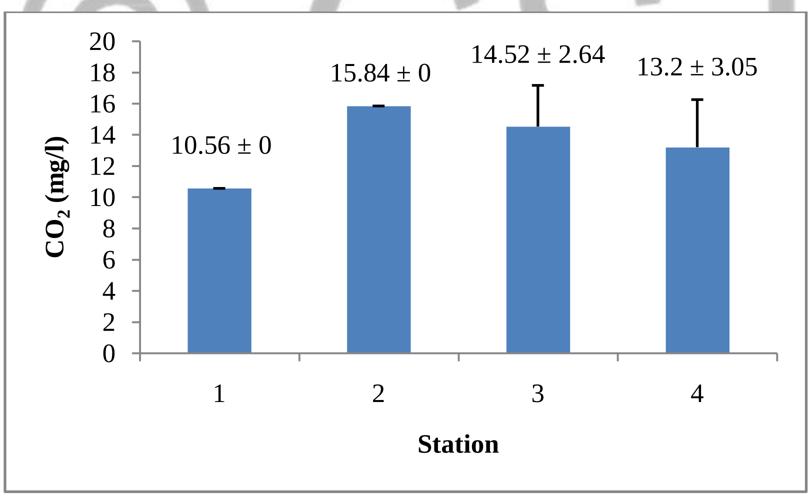

Figure 5. The carbon dioxide graphs in waters during research

3.5 Biochemical oxygen demand

The average BOD_5 concentration of Darma Reservoir waters is around 18 ± 0.82-18.75 ± 0.96 mg/l (Figure 6). The waters of the Darma Reservoir are classified as polluted by organic material because the BOD_5 concentration exceeds the quality standards specified by Government Regulation No. 82, 2001, that is 3-6 mg/l for fish farming [5]. BOD_5 concentration in natural waters between 0.5-7.0 mg/l and waters that have a BOD5 more than 10 mg/l are considered to have pollution [10]. Stations 2 and 4 have the same BOD_5 concentration, that is 18.75 ± 0.96 mg/l and higher than station 1 and station 3, it happens because of waste that enters in conjunction with the water flow, there are also intensive floating net cages aquaculture activities at station 2, while station 4 receives input from the surrounding agricultural activities so that the amount of oxygen needed by microorganismsto degrade organic waste is high.

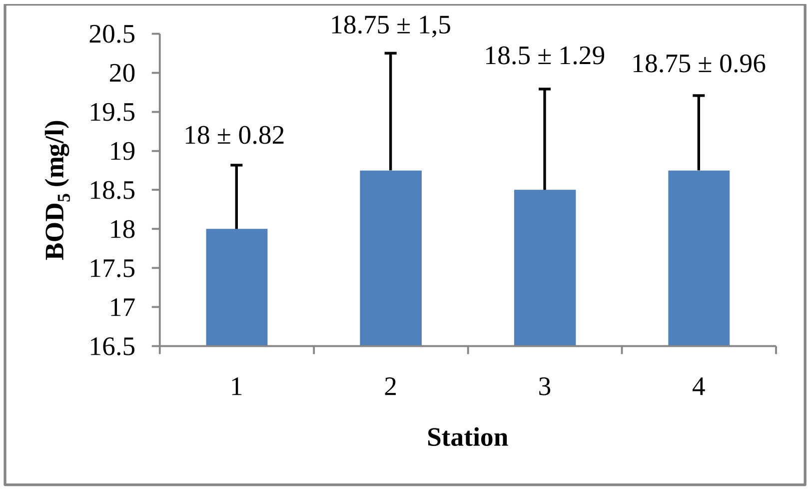

Figure 6. The biochemical oxygen demand graphs in waters during research

3.6 Dissolved oxygen

The average dissolved oxygen concentration in the waters of the Darma Reservoir is around 5.18 ± 0.24-6.05 ± 0.13 mg/l. The oxygen concentration is still within the limits of class II water quality standards in Government Regulation No. 82, 2001, that is 4 mg/l [5]. Waters designated for fishery purposes should have an oxygen concentration of not less than 5 mg / L [9]. The lowest average dissolved oxygen concentration at station 2. It is due to the dense use of reservoir especially for floating net cages aquaculture activities so that the amount of organic waste (feed waste and metabolic waste) is produced. According to the rate of oxygen consumption in floating net cages aquaculture is twice as high as the rate of oxygen consumption in waters where there is no floating net cages [11].

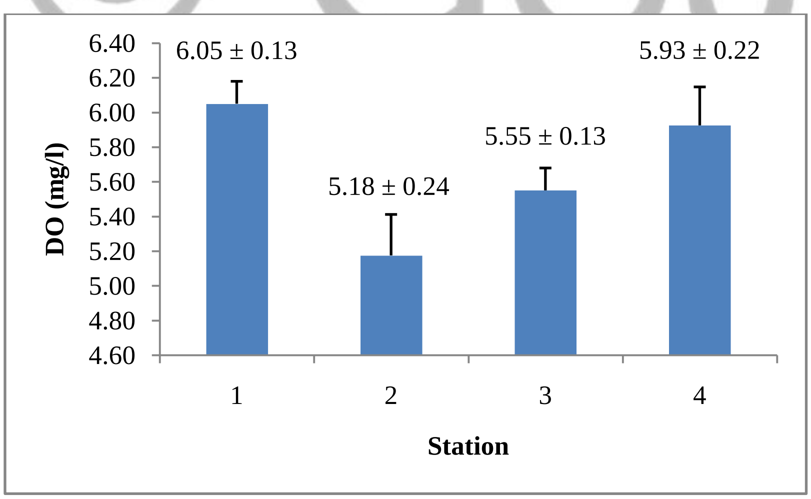

Figure 7. The dissolved oxygen graphs in waters during research

3.7 Ammonia

The average concentration of ammonia in the waters of the Darma Reservoir ranged from 0.663 ± 0.074-0.87 ± 0.151 mg/l (Figure 8). Ammonia concentration has exceeded the class II water quality standard in Government Regulation No. 82, 2001, that is ≤0.02 mg/l for sensitive fish such as carp [5]. Free ammonia concentrations exceeding 0.2 mg/l are toxic to several fish species, in addition high ammonia concentrations can be used as an indication of organic pollution originating from domestic waste and fertilizer agriculture [12]. The highest average ammonia concentration is found in stations that have high floating net cages aquaculture compared to other stations, which is station 2. The high concentration of ammonia is thought to originate from the results of the removal of floating net cages aquaculture (feed waste and metabolic waste) found at the station. The concentration of ammonia in waters generally comes from decomposition organic material and fish metabolic waste. The higher the organic matter in the waters, the higher the ammonia concentration [13].

3.8 Total phosphorus

The average total phosphorus in Darma Reservoir waters ranged from 0.293 ± 0.087-0.393 ± 0.116 mg/l (Figure 9). The total phosphorus concentration has exceeded the Class II water quality standard for fish farming according to Government Regulation No. 82, 2001, that is 0.2 mg/l. The highest total phosphorus concentration was found in research sites with high floating net cages aquaculture (station 2) because it would contribute to the phosphorus derived from feed waste and fish metabolic waste. The concentration of P in the faeces was 20% -50% [14] and the concentration of P in the urine was 65% [15]. The waters of the Darma Reservoir can be classified into waters with high fertility rates.

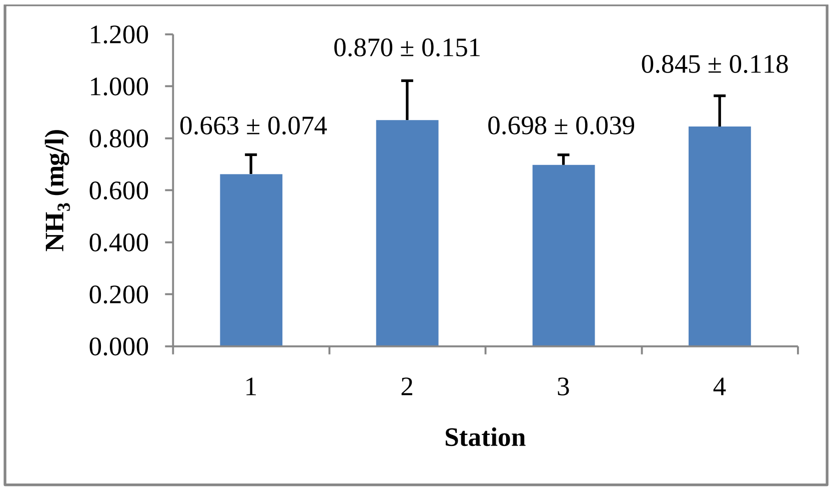

Figure 8. The ammonia graphs in waters during research

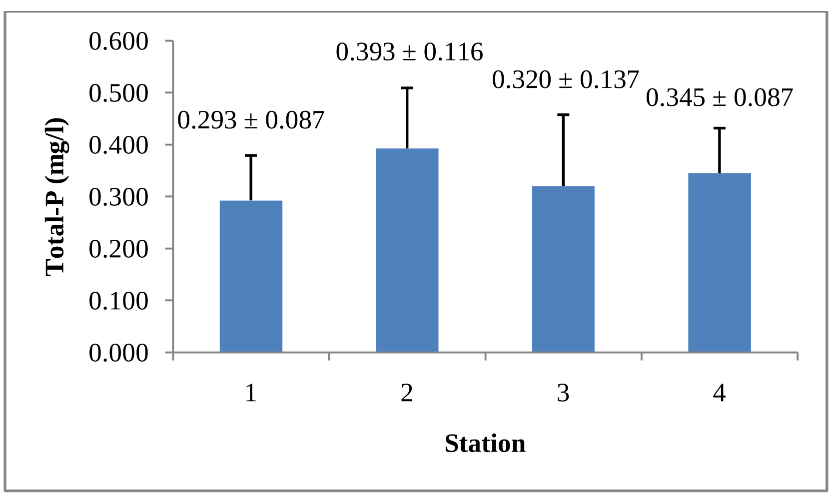

Figure 9. The total phosphorus graphs in waters during research

3.9 Carrying capacity of Darma Reservoir

The existence of floating net cages in the Darma Reservoir currently amounts to 2,614 units or 10,456 bags. In general, the size of each floating net cage unit is 7m x 7m x 6m (294 m^3) and most of it is concentrated around station 2 (Jagara Village) and station 3 (Cikupa Village). Most of fish that being raised in the floating net cages are carp (*Cyprinus carpio*) and tilapia (*Oreochromis niloticus*). Stocking density of seeds around ± 400 kg/unit (± 8,000 fish) with a pisciculture period about 3 months, the use of feed as much as 3 tons/cycle to produce fish around 1.2 tons/cycle.

If the floating net cages operates as many as 10,456 bags, the number of fish in the floating net cages is as much as 1,045.6 tons when the seeds are first stocked. Thus, the amount of feed given to 10,456 bags was 31,368 tons/year. In intensive fish farming, the amount of feed given as much as 30-40% is wasted into the waters [16]. Based on these estimates, the amount of wasted feed is 9,410.4 tons/year or 25.78 tons/day.

The results of observational data in the Darma Reservoir, the amount of feed used reached 85.94 tons/day. Only 70% of the feed used is eaten by fish. The total phosphorus concentration in commercial feed is 1.2% [17], so the feed in the Darma Reservoir has the potential to produce a total phosphorus in the waters of 1,031.28 kg/day. Based on these calculations, reservoir waters receive organic waste discharges from floating net cages totaling 234,507.2 kg containing phosphorus, or in other words every liter of water in the reservoir is polluted with organic waste from floating net cages of 17.6 µg every day (Table 1).

According to the calculation of the capacity in the Darma Reservoir, the maximum number of floating net cages that can operate is only 3.068 bags. It shows that there was an excess of 7.388 bags (Table 2). The amount of floating net cages that exceeds the Darma Reservoir capacity has resulted in decreased water quality. The decreased water quality is indicated by the concentration of ammonia (NH_3) and total phosphorus that exceeds the water quality standard set for pisciculture. As a result of the decreased in water quality, the current yield of fish is less than the maximum due to the frequent occurrence of mass death of fish during the rainy season due to *turn over*, and in the end the fish will be sold at a low price on the market. Reducing the amount of floating net caged in accordance with the capacity of waters of the Darma Reservoir is one of the controls of water pollution so that the utilization and management of fish resources can be sustainable.

Tabel 1. Prediction of total phosphorus supply from floating net cages aquaculture in Darma Reservoir

No.	Parameter	Unit	Reservoir	Information
	Feed Data			
1.	FCR		1,8	
2.	Total feed/year	kg/year	31,368,000	70% consumed, 30% wasted
	Total feed wasted	kg/year	9,410,400	
	Total P Data			
3.	P in feed	kg	376.416	1.2% of feed weight
4.	P in fish	kg	141.908,8	37.7% of the concentration of P feed
5.	P discharged through faeces	kg	79.047,4	21% of the concentration of P feed
6.	P wasted dissolved from metabolic residual	kg	155.459,8	41,3% of the concentration of P feed
7.	Waste load P is discharged into the reservoir	kg/year	234.507,2	$P_{feed} – P_{fish}$
		kg P/year	13,4568	Fish produced
		µg/l/day	6.424,85	17,6 µg/l/day

Tabel 2. Calculation of Darma Reservoir capacity

No.	Parameter	Unit	Value
1.	The average depth of reservoirs (Z)	M	14
2.	Volume of water reservoir (V)	million m^3	36,5
3.	Area of reservoir (A)	Ha	425
4.	Number of discharge water reservoirs out (Q)	million m^3 /year	94,61
5.	Rate of water change of reservoir (ρ)	per year	2,59
6.	The maximum P concentration that can be accepted by water bodies ([P]f), for common carp and tilapia 250 mg/m^3	mg/m^3	250
7.	Total phosphorus parameters of monitoring results of reservoir ([P]i)	mg/m^3	337,5
8.	Total phosphorus allocation of fish farming Δ [P]	mg/m^3	87,5
9.	Total phosphorus left with sediment (R)	mg P/m^3	0,455
10.	The proportion of Total phosphorus that dissolves into the sediment after the cage is present (R_{fish}), x assumption: 45-55%.	mg P	0,728
11.	Total phosphorus fish waste capacity per unit of reservoir area (L_{fish})	g P/m^3	11,6645
12.	Total capacity of Total phosphorus fish waste in lake waters (La_{fish})	g P/year	4.957,4 x 106
13.	Total phosphorus entering the reservoir from the fish waste (P_{LP})	kg P/ton of fish	13,4568
14.	Total production of net cage culture (LI)	tons of fish/year	3.683,06
15.	Total feed of net cage culture (LP)	ton of feed/year	6.629,50

© GSJ

3 CONCLUSIONS

The number of floating net cages aquaculture system in the Darma Reservoir has exceeded the reservoir's carrying capacity. Feed waste from fish farming contributes to 234.507.2 kg / year (17.6 µg/l/day) of the pollution load. The decrease in water quality is caused by an abundance of wasted food waste (155,459.8 kg P/year) and metabolic or faecal residues (79,047.4 kg P/year). The number of floating net cages in the Darma Reservoir has exceeded the reservoir capacity by 10,456 bags which should only be allowed as many as 3.068 bags.

GSJ: Volume 8, Issue 7, July 2020
ISSN 2320-9186

References

[1] Tjahyo, DW H and A. Warsa. 2019. *Management of Fisheries Resources in the Darma Reservoir: Structuring of Floating Net Cages and Development of Smart Floating Net Cages and Culture Based Fisheries*. Research Center for Recovery of Fish Resources. Ministry of Maritime Affairs and Fisheries.

[2] Nuryaman. 2018. *Natural Water Surface Temperature Decreases, Tens of Tons of KJA Fish in Darma Reservoir Dead Bulk*. Available at Kuningankab.go.id.

[3] Abduh, M. 2004. *Culture Based Fisheries Program*. Aquaculture Research Center. Maritime and Fisheries Research Agency. The Ministry of Marine Affairs and Fisheries. Jakarta.

[4] Siagian, M. 2010. Carrying Capacity of Kampung Koto Panjang Reservoir in Kampar, Riau Province. *Journal of FISHERIES and MARINE* 15 (1) : 25-38.

[5] Government Regulation of the Republic of Indonesia Number. 82 of 2001, concerning *Water Quality Management and Pollution Control*. Jakarta.

[6] Boyd, C. E. 2001. *Water Quality in Ponds for Aquaculture. Birmingham*. Publishing Co. Birmingham, Alabama.

[7] Andria, AF and S. Rahmaningsih. 2018. Technical Study of Abiotic Factors in Clay Embankment Used at PT. Semen Indonesia Tbk. for Utilization of Fish Cultivation with KJA Technology. *Scientific Journal of Fisheries and Marine Sciences (JIPK)* 10 (2).

[8] Sukabumi Freshwater Aquaculture Development Center. 2016. *Freshwater Quality Standards*. Agromedia. Jakarta.

[9] Effendi, H. 2003. *Water Quality Study for Water Resources and Environmental Management*. PT. Kanisius. Yogyakarta.

[10] Setiari, I. M. 2012. Identification of Pollutant Sources and Analysis of Tukad Yeh Sungai Water Quality in Tabanan Regency by Pollution Index Method. *Thesis*. Udayana University. Bali.

[11] Beveridge, M. C. M. 1996. *Cage Aquaculture. 2nd Edition*. Fishing News Books LTD. Farnham, Surrey, England 352 p.

[12] Minggawati, I and Saptono. 2012. Water Quality Parameters for Catfish Cultivation (*Pangasius pangasius*) in the Kahayan River Karamba in Palangka Raya City. *Journal of Tropical Animal Science* 1 (1) : 27-30.

[13] Makmur, M., H. Kusnoputranto, SS Moersidik, DS Wisnubroto. 2012. The Effect of Organic Waste and N / P Ratio on Phytoplankton Abundance in Cilincing Green Shell Cultivation Area. *Journal of Waste Management Technology* 15 (2) : 51-64.

[14] Vinneras, B. 2006. Faecal separation and urine diversion for nutrient management of household biodegradable waste and wastewater. *Thesis*. Uppsala: Swedish University of Agricultural Sciences.

[15] Jonsson, H. 1997. Assessment of sanitation systems and reuse of urine. ecological alternatives in sanitation. proceedings from sida sanitation workshop. Publications on Water Resources. Balingsholm, Sweden 11–22 p.

[16] Technology Assessment and Application Board (BPPT). 1997. Floating Net Cage Fisheries Business System with Superior Strains and Floating Net Technology. *Research Report*. Fisheries Research and Development Center. Jakarta.

[17] Garno, Y. S and TA Adibroto. 1999. The Impact of Fish Fattening in Multipurpose Reservoir Water Bodies on Water Quality and Potential Reservoirs. National Seminar and Workshop Preservation of Lake and Reservoir Management and Utilization. *IPB-Directorate General of Irrigation-Ministry of Environment* 17 : 1-10.