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Analysis of The Effect of Floating Net Cages on Reservoir Water Quality (Case Study: Darma Kuningan Reservoir, Indonesia)

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Abstract:
The use of Darma Waduk is as a source of clean water and a place of fish cultivation in the form of net cages. The number of floating net cages that currently exist is 6521, and the number continues to increase quite significantly from the previous year. The existence of floating net cages affects water quality, while water quality is an aspect to be considered in water utilization. The study aims to analyze the impact of floating net cages on water quality and efforts to control the floating net cage population in Darma Waduk. The research uses a quantitative and qualitative approach, starting with surveys and interviews with floating net cage farmers and related services. Subsequently, water samples were taken, and the results of laboratory tests were analyzed using the Pollution Index (IP) method. The results of the calculation using the pollution index (IP) method at the first point (PDAM Intake Area) obtained a result of 4.14, at the second point (around the floating net cage area of the village of Cipasung) a value of 3.76, and at the third point (in the floating net cage village of Jagara) a score of 4.12. The results of the research showed that the water quality taken from the three points of the sample included light pollution when referring to the class I water quality standard according to PP No. 22 for 2021. However, the presence of household and agricultural waste also contributes to the pollution burden in the Darma Valley.

Keywords: (Water Quality, Floating Net Cages, Pollution Index)

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INTRODUCTION

Darma Reservoir is included in the category of multipurpose reservoirs, where it is based on the use of reservoir water as a clean water provider, irrigation water provider, fish cultivation using the floating net cage method (KJA), and for drinking water services (PDAM) (Weerahewa et al., 2023). The problems faced in water resource management are water shortages, excess water, and water pollution. The lack of good institutions in the Darma Reservoir causes the KJA population to be uncontrollable, which can affect the quality of the waters (Purba & Nurhayati, 2022). Ideally, the characteristics of clean water are clear, odorless, and colorless, and they do not contain pathogenic germs that can endanger human health (Kayan, 2015). Fish cultivation with the floating net cage method (KJA) has an impact on the obstruction of water flow and currents for the transportation of oxygen, sediment, and plankton, as well as fish larvae (Syandri, Azrita, & Mardiah, 2020). The impact arising from the existence of the KJA is in the form of eutrophication of reservoir water quality and a high sediment rate (Mushfiroh & Marselina, 2021). The problem that often arises due to excess KJA is the mass death of fish due to the upwelling event.The upwelling *event* is caused by the suboptimal circulation of the bottom water, resulting in a decrease in the level of dissolved oxygen in the water.

Table 1. Development of the Number of Floating Net Cages

No	Year	Number of Floating Net Cages
1	2020	4916
2	2021	6986
3	2022	6521
4	2023	6521

Source : Dinas Perikanan dan Pertanian Kab. Kuningan

Based on Table 1, it shows that from 2020 to 2021, there was a significant increase in the number of floating net cages (KJA). Meanwhile, from 2022 to 2023, the number of KJAs will remain stable. However, this number has exceeded the maximum limit allowed for KJA in reservoirs according to Regent Regulation Number 81 of 2020, where the maximum limit for KJA is 1,500 plots with a tolerance limit of 2,500 plots. From this, the problem of the level of pollution in the Darma Reservoir arises: how to control the population of the increasing number of KJA? Therefore, it is necessary to conduct research on the analysis of the influence of floating net cages on the water quality of the Darma Reservoir.

Global issues related to fish farming in floating net cages (KJA) and its impact on water quality have become a widespread concern in various parts of the world (Iskandar, Sumiarsa, Suwartapradja, & Kamarudin, 2024). Several studies have shown that the presence of FECs can cause eutrophication, sedimentation, and significant water quality degradation in many reservoirs and lakes (Kusliansjah, Gunawan, Tjong, & Yudianto, 2023). Globally, the growth of the aquaculture industry, including fish farming in KJAs, has increased rapidly in recent decades to meet the growing demand for fish (FAO, 2020). However, unsustainable aquaculture practices can pose serious environmental problems.

Several previous studies have examined the impact of KJA on water quality in various reservoirs and lakes. (Syandri et al., 2020) found that KJA in Lake Maninjau, Indonesia, had caused water quality degradation, eutrophication, and fish health problems. (Mushfiroh & Marselina, 2021) also reported that KJA in Darma Reservoir had caused eutrophication and increased sedimentation rates. In Thailand, (Weerahewa et al., 2023) showed that the presence of KJAs has caused a decline in water quality in Beung Boraphet Lake.

This research has several novelty aspects that distinguish it from previous studies, namely: Focuses on analyzing the impact of KJA on water quality in Darma Reservoir, Indonesia, which is an important source of drinking and irrigation water for the local community. Uses a comprehensive approach, i.e. a combination of quantitative (pollution index) and qualitative (interviews with farmers and relevant stakeholders) analysis. Provided concrete recommendations for efforts to control the KJA population in Darma Reservoir to maintain the sustainability of water resources.

The purpose of this study is to find out how the existing conditions of water quality in the Darma Reservoir are based on physical and chemical parameters; discuss the difference in water quality between reservoirs with floating net cages (KJA) and those without floating net cages; and discuss how efforts were made to control the number of floating net cages (KJA). The results of this study are expected to contribute to the management of the Darma Reservoir and can be used as evaluation material for how efforts are made to control the KJA population.

RESEARCH METHODS

This research was conducted in the Darma Reservoir, Kuningan Regency, West Java. The Darma Reservoir has an inundation area of 309 ha. The data used in this study are in the form of primary and secondary data. Primary data was obtained from observations, measurements, and direct interviews with resource persons (floating net cage farmers and related agencies) during the study. The primary data collected was in the form of data on water quality results (physical parameters and kimia). As for the secondary data needed, the data on the number of KJA in recent years from related agencies serves as supporting data for this study.

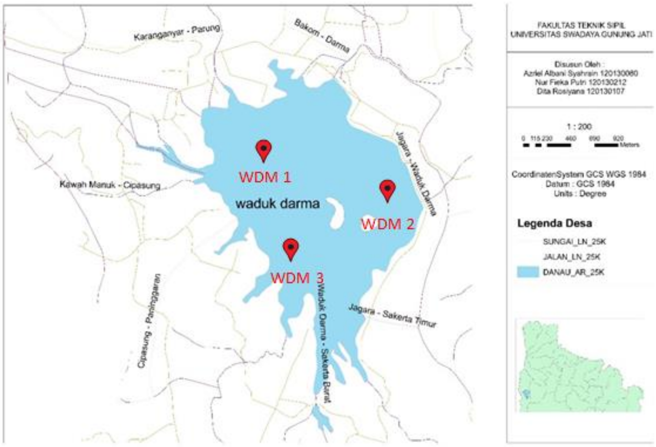

Figure 1. Research Location and Sampling Point Plan

The research began with the collection of technical data and interviews with KJA farmers and related agencies, such as the Darma Reservoir Management Office and the Fisheries and Agriculture Office of Kuningan Regency. Furthermore, observations were made in the field, and sampling points were determined based on the purpose of the research (purposive sampling). Sampling was carried out at the first point, namely WDM 1, the second point, namely WDM 2, and the third point, namely WDM 3. From the results obtained, the data is then processed using the Pollution Index (IP) method so that the standard status of water quality can be known (Romdania, Herison, & Susilo, 2018).

Table 2. Determination of Water Quality Standard Status

No	Score IP	Description
1	0 - 1,0	Good Condition
2	1,1 - 5,0	Light Contamination
3	5,1 - 10	Moderate Pollution
4	>10	Heavy Contamination

Source : Peraturan Pemerintah No.22 Tahun 2021

This index shows one type of parameter that is dominant in causing a decrease in water quality in one observation. According to Government Regulation Number 22 of 2021 concerning the determination of water quality analysis, the level of pollution can be determined using the following formula:

Pij = = $\sqrt{\left(\frac{Ci}{Lij}\right)^2 M + \left(\frac{Ci}{Lij}\right)^2 R} \Big/ 2$

$$\left(\frac{Ci}{Lij}\right)M = \frac{Nilai\ Ci}{Lij}\ Max$$

$$\left(\frac{Ci}{Lij}\right)R = \frac{Nilai\ Ci}{Lij}\ rata - rata$$

Information:
Ci = Concentration of water quality parameters from the survey results
Li = Concentration of water quality parameters in Water Quality Standards (j)
PIj = Pollution index for allocation (j)

RESULTS AND DISCUSSION

Rainfall Data Analysis

The rainfall data used in this study was obtained from the Cimanuk-Cisanggarung River Area Center (BBWS). Rainfall data was taken, namely 10-year rainfall data from Darma Station in accordance with the research site, along with the average annual rainfall data at Darma Station:

Table 3. 10-Year Rainfall Data at Darma Station

YEAR	AMOUNT PER YEAR	AVERAGE PER YEAR
2011	183.913	7.663
2012	168.177	7.007
2013	178.367	7.432
2014	217.063	9.044
2015	176.480	7.353
2016	140.158	5.840
2017	131.127	5.464
2018	196.450	8.185
2019	181.642	7.568
2020	181.708	7.571
SUM	**1755.087**	
AVERAGE	**175.509**	

Source : Calculation results

Table 3 shows that the amount of rainfall per year, namely in 2011–2020, ranges from 131,127 mm to 217,063 mm, while the average per year ranges from 5,464 to 9,044 mm. Meanwhile, the average in 10 years is 175,509 mm.

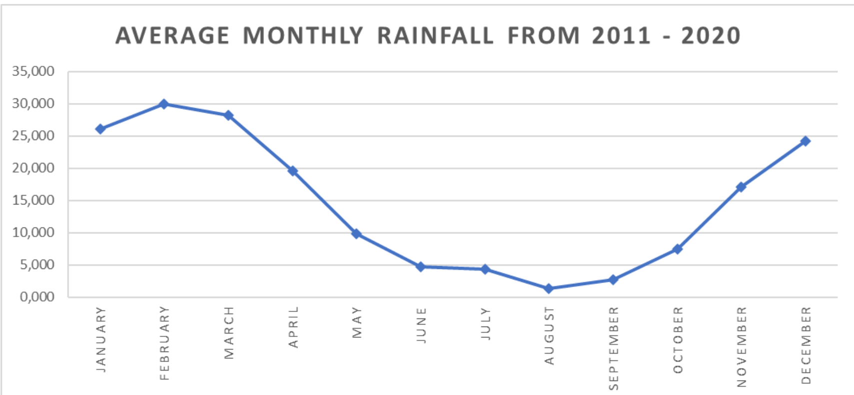

Figure 2. Average Rainfall

Based on the analysis of rainfall, it can be known that the average monthly rainfall from 2011 to 2020 shows that in March, at the time of sampling, the rainfall was still high; next, in July, subsequent sampling of rainfall tends to be smaller; and in December, the average rainfall in 10 years is high. From this data, it may be possible to compare whether there is a difference in water quality between the dry season and the rainy season.

Debit Outflow Data Analysis

The debit data used is outflow debit or outgoing discharge. Outflow discharge is obtained from the sum of expenses such as from culverts, seepage, overflow and for PDAM Kuningan water. The following is the outflow debit data in 10 years:

Table 4. 10 Years Debit Outflow Data

YEAR	AMOUNT PER YEAR	AVERAGE PER YEAR (M^3/sec)
2013	306.225	12.759
2014	407.678	16.987
2015	661.552	27.565
2016	353.759	14.740
2017	548.338	22.847
2018	514.936	21.456
2019	335.751	13.990
2020	502.954	20.956
2021	641.372	26.724
2022	633.373	26.391
2023	653.181	27.216
SUM	**231.630**	
AVERAGE	**21.057**	

Source : Calculation results

Based on **Table 4**, it can be seen that the average outflow discharge issued in 10 years is worth 21,057 m3/sec. This value is obtained from the average every year, where the average value every year ranges from 12,759 – 27,565 m3/sec.

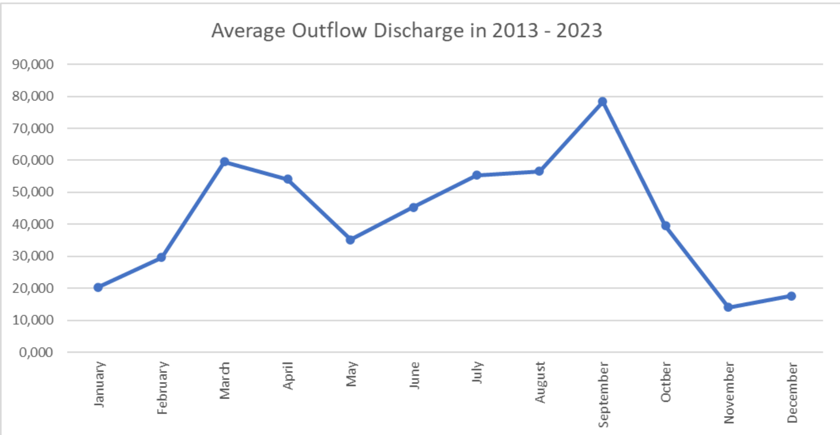

Figure 3. Average Amount of Outflow Discharge

Based on the analysis of discharge outflow data at Darma Reservoir, it can be known that the monthly average from 2011 – 2020 shows that the results are inversely proportional to the amount rain. Where in July rainfall tends to be less but the outflow discharge is high, while in December the outflow discharge value is less.

Analysis of Test Values based on Physical and Chemical Parameters

After calculating rainfall data and outflow discharge data, then conducting water quality testing based on physical and chemical parameters, the following water quality test values based on physical and chemical parameters:

Table 5. Test Values of Aquatic Physical and Chemical Parameters Darma Reservoir in 2021

No	Parameter	WDM 1	WDM 2	WDM 3	Unit	Water Quality Class Quality Standards			
						I	II	III	IV
1	Odor	Odorless	Odorless	Odorless	–	–	–	–	–
2	Fosfat	0,17	0,17	0,109	mg/L	0,2	0,2	1	–
3	TSS	9	9	9	mg/L	40	50	100	400
4	pH	8,7	8,7	7,98	–	6 – 9	6 – 9	6 – 9	6 – 9
5	BOD	5,7	5,7	4,27	mg/L	2	3	6	12
6	COD	16,3	16,3	12,2	mg/L	10	25	40	80
7	DO	6,1	6,1	7,1	mg/L	6	4	3	1
8	Nitrate, as N	0,317	0,317	0,317	mg/L	10	10	20	20
9	Focal Colliform	60	60	420	mg/L	100	1000	2000	200

Source : Balai Besar Wilayah Sungai Cimanuk Cisanggarung

Table 6. Test Values of Aquatic Physical and Chemical Parameters Darma Reservoir in 2023 (July Period)

No	Parameter	WDM 1	WDM 2	WDM 3	Unit	Water Quality Class Quality Standards			
						I	II	III	IV
1	Odor	Odorless	Odorless	Odorless	–	–	–	–	–
2	pH	7	8,14	7,28	–	6 – 9	6 – 9	6 – 9	6 – 9
3	Focal Colliform	0	0	10	mg/L	100	1000	2000	200
4	Nitrate, as N	3,55	1,48	0,89	mg/L	10	10	20	20
5	Fosfat	0,97	0,99	0,81	mg/L	0,2	0,2	1	–
6	TSS	3,3	0,2	0,3	mg/L	40	50	100	400
7	DO	3,6	4,3	3,7	mg/L	6	4	3	1
8	BOD	2,1	2,22	3,3	mg/L	2	3	6	12
9	COD	7	7,7	5,7	mg/L	10	25	40	80

Source : Balai Besar Wilayah Sungai Cimanuk Cisanggarung

Table 7. Test Values of Aquatic Physical and Chemical Parameters Darma Reservoir in 2023 (December Period)

No	Parameter	WDM 1	WDM 2	WDM 3	Unit	Water Quality Class Quality Standards			
						I	II	III	IV
1	Odor	Odorless	Odorless	Odorless	–	–	–	–	–
2	pH	7,2	7,7	6,6	–	6 – 9	6 – 9	6 – 9	6 – 9
3	Focal Colliform	16	46	58	mg/L	100	1000	2000	200
4	Nitrate, as N	0,14	0,06	1,07	mg/L	10	10	20	20
5	Fosfat	0,14	0,15	0,17	mg/L	0,2	0,2	1	–
6	TSS	2,5	2,5	14	mg/L	40	50	100	400
7	DO	2,1	2,3	3,8	mg/L	6	4	3	1
8	BOD	2,13	2,07	3,21	mg/L	2	3	6	12
9	COD	7,1	6,9	10,7	mg/L	10	25	40	80

Source : Balai Besar Wilayah Sungai Cimanuk Cisanggarung

Table 8. Test Values of Aquatic Physical and Chemical Parameters Darma Reservoir in 2024 (March)

No	Parameter	WDM 1	WDM 2	WDM 2	Unit	Water Quality Class Quality Standards			
						I	II	III	IV
1	Odor	Odorless	Odorless	Odorless	–	–	–	–	–
2	Kekeruhan	8,82	8,07	7,59	NTU	–	–	–	–
3	Temperatur	28,9	28,7	28,9	ºC	Dev 3	Dev 3	Dev 3	Dev 3
4	Warna	40	38	36	Skala TCU	15	50	100	–
5	TDS	73	72	74	mg/L	1000	1000	1000	2000
6	TSS	21	15	9	mg/L	40	50	100	400
7	Ph	7,38	7,47	7,43	–	6 – 9	6 – 9	6 – 9	6 – 9
8	BOD	16,5	12,8	16,1	mg/L	2	3	6	12
9	COD	35	29	34	mg/L	10	25	40	80
10	DO	5,5	4,5	4,1	mg/L	6	4	3	1
11	Nitrate, as N	1,3	1,1	1,3	mg/L	10	10	20	20
12	Nitrite, as N	0,04	0,04	0,04	mg/L	0,06	0,06	0,06	(–)

Source : Personal Documents

Information ;

WDM 1 : Sample Point 1
WDM 2 : Sample Point 2
WDM 3 : Sample Point 3

Based on tables 5 - 8, it shows the results of physical and chemical parameter tests that have been carried out from 2021, 2023 and 2024. Table 5 shows that the test results have several parameters that exceed the maximum limit of class I water quality standards according to Government Regulation Number 22 of 2021, namely COD, BOD and DO parameters (Wikurendra, Syafiuddin, Nurika, & Elisanti, 2022). Furthermore, seen from tables 6 – 7, the test results in 2023 for the July and December periods show that the BOD and COD parameters exceed the maximum limit of class I water quality standards (Arisanty, Hastuti, Adyatma, & Azhari, 2021).

Analysis of Darma Reservoir Water Quality Using the Pollution Index (IP) Method

After obtaining the test results, the next step is to calculate using the Pollution Index (IP) method to find out the standard status of the water quality as follows:

Table 9. Results of the Calculation of the Pollution Index (IP) of the Darma Reservoir in 2021 (WDM 1)

No	Parameter	Ci	Unit	Li	Unit	Ci/Li	Ci/Li New
1	Odor	Odorless	–	–	–	–	–
2	Fosfat	0,4	mg/L	0,2	mg/L	2,00	2,51
3	TSS	9	mg/L	40	mg/L	0,23	0,23
4	pH	8,38	–	6 – 9	–	0,59	0,59
5	BOD	2,55	mg/L	2	mg/L	1,28	1,53
6	COD	7,29	mg/L	10	mg/L	0,73	0,73
7	DO	4,7	mg/L	6	mg/L	2,30	2,81
8	Nitrate, as N	2,5	mg/L	10	mg/L	0,25	0,25
9	Focal Colliform	270	mg/L	100	mg/L	2,70	3,16
Sum							9,28
Maximum							3,16
Average							1,47
IP							2,46
Information							Lightly polluted

Source : Calculation Results

Table 10. Results of the Calculation of the Pollution Index (IP) of the Darma Reservoir in 2021 (WDM 2)

No	Parameter	Ci	Unit	Li	Unit	Ci/Li	Ci/Li New
1	Odor	Odorless	–	–	–	–	–
2	Fosfat	0,17	mg/L	0,2	mg/L	0,85	0,85
3	TSS	9	mg/L	40	mg/L	0,23	0,23
4	pH	8,7	–	6 – 9	–	0,80	0,80
5	BOD	5,7	mg/L	2	mg/L	2,85	3,27
6	COD	16,3	mg/L	10	mg/L	1,63	2,06
7	DO	6,1	mg/L	6	mg/L	0,90	0,77
8	Nitrate, as N	0,317	mg/L	10	mg/L	0,03	0,03
9	Focal Colliform	60	mg/L	100	mg/L	0,60	0,60
Sum							7,76
Maximum							3,27
Average							1,08
IP							2,44
Information							Lightly polluted

Source : Calculation Results

Table 11. Results of the Calculation of the Pollution Index (IP) of the Darma Reservoir in 2021 (WDM 3)

No	Parameter	Ci	Unit	Li	Unit	Ci/Li	Ci/Li New
1	Odor	Odorless	–	–	–	–	–
2	Fosfat	0,109	mg/L	0,2	mg/L	0,55	0,55
3	TSS	9	mg/L	40	mg/L	0,23	0,23
4	pH	7,98	–	6 – 9	–	0,32	0,32
5	BOD	4,27	mg/L	2	mg/L	2,14	2,65
6	COD	12,2	mg/L	10	mg/L	1,22	1,43
7	DO	7,1	mg/L	6	mg/L	1,18	1,37
8	Nitrate, as N	0,317	mg/L	10	mg/L	0,03	0,03
9	Focal Colliform	420	mg/L	100	mg/L	4,20	4,12
Sum							10,14
Maximum							4,12
Average							1,34
IP							3,06
Information							Lightly polluted

Source : Calculation Results

Table 12. Results of the Darma Reservoir Pollution Index Calculation Year 2023 July Period (WDM 1)

No	Parameter	Ci	Unit	Li	Unit	Ci/Li	Ci/Li New
1	Odor	Odorless	–	–	–	–	–
2	pH	7	–	6 – 9	–	0,33	0,33
3	Focal Colliform	0	mg/L	100	mg/L	0	0
4	Nitrate, as N	3,55	mg/L	10	mg/L	0,36	0,36
5	Fosfat	0,97	mg/L	0,2	mg/L	4,85	4,43
6	TSS	3,3	mg/L	40	mg/L	0,08	0,08
7	DO	3,6	mg/L	6	mg/L	3,40	3,66
8	BOD	2,1	mg/L	2	mg/L	1,05	1,11
9	COD	7	mg/L	10	mg/L	0,70	0,70
Sum							10,66
Maximum							4,43
Average							1,33
IP							3,27
Information							Lightly polluted

Source : Calculation Results

Table 13. Results of the Darma Reservoir Pollution Index Calculation Year 2023 July Period (WDM 2)

No	Parameter	Ci	Unit	Li	Unit	Ci/Li	Ci/Li New
1	Odor	Odorless	–	–	–	–	–
2	pH	8,14	–	6 – 9	–	0,43	0,43
3	Focal Colliform	0	mg/L	100	mg/L	0	0
4	Nitrate, as N	1,48	mg/L	10	mg/L	0,15	0,15
5	Fosfat	0,99	mg/L	0,2	mg/L	4,95	4,47
6	TSS	0,2	mg/L	40	mg/L	0,01	0,01
7	DO	4,3	mg/L	6	mg/L	2,70	3,16
8	BOD	2,22	mg/L	2	mg/L	1,11	1,23
9	COD	7,7	mg/L	10	mg/L	0,77	0,77
Sum							10,21
Maximum							4,47
Average							1,28
IP							3,29
Information							Lightly polluted

Source : Calculation Results

Table 14. Results of the Darma Reservoir Pollution Index Calculation Year 2023 July Period (WDM 3)

No	Parameter	Ci	Unit	Li	Unit	Ci/Li	Ci/Li New
1	Odor	Odorless	–	–	–	–	–
2	pH	7,28	–	6 – 9	–	0,15	0,15
3	Focal Colliform	10	mg/L	100	mg/L	0,1	0,1
4	Nitrate, as N	0,89	mg/L	10	mg/L	0,09	0,09
5	Fosfat	0,81	mg/L	0,2	mg/L	4,05	4,04
6	TSS	0,3	mg/L	40	mg/L	0,01	0,01
7	DO	3,7	mg/L	6	mg/L	3,30	3,59
8	BOD	3,3	mg/L	2	mg/L	1,65	2,09
9	COD	5,7	mg/L	10	mg/L	0,57	0,57
Sum							10,63
Maximum							4,04
Average							1,33
IP							3,01
Information							Lightly polluted

Source : Calculation Results

Table 15. Results of the Darma Reservoir Pollution Index Calculation Year 2023 December Period (WDM 1)

No	Parameter	Ci	Unit	Li	Unit	Ci/Li	Ci/Li New
1	Odor	Odorless	–	–	–	–	–
2	pH	7,2	–	6 – 9	–	0,20	0,20
3	Focal Colliform	16	mg/L	100	mg/L	0,16	0,16
4	Nitrate, as N	0,14	mg/L	10	mg/L	0,01	0,01
5	Fosfat	0,14	mg/L	0,2	mg/L	0,70	0,70
6	TSS	2,5	mg/L	40	mg/L	0,06	0,06
7	DO	2,1	mg/L	6	mg/L	4,90	4,45
8	BOD	2,13	mg/L	2	mg/L	1,07	1,14
9	COD	7,1	mg/L	10	mg/L	0,71	0,71
Sum							7,43
Maximum							4,45
Average							0,93
IP							3,22
Information							Lightly polluted

Source : Calculation Results

Table 16. Results of the Darma Reservoir Pollution Index Calculation Year 2023 December Period (WDM 2)

No	Parameter	Ci	Satuan	Li	Satuan	Ci/Li	Ci/Li New
1	Bau	Tidak Berbau	–	–	–	–	–
2	pH	7,7	–	6 – 9	–	0,13	0,13
3	Focal Colliform	46	mg/L	100	mg/L	0,46	0,46
4	Nitrate, as N	0,06	mg/L	10	mg/L	0,01	0,01
5	Fosfat	0,15	mg/L	0,2	mg/L	0,75	0,38
6	TSS	2,5	mg/L	40	mg/L	0,06	0,06
7	DO	2,3	mg/L	6	mg/L	4,70	4,36
8	BOD	2,07	mg/L	2	mg/L	1,04	1,07
9	COD	6,9	mg/L	10	mg/L	0,69	0,69
Sum							7,16
Maximum							4,36
Average							0,90
IP							3,15
Information							Lightly polluted

Source : Calculation Results

Table 17. Results of the Darma Reservoir Pollution Index Calculation Year 2023 December Period (WDM 3)

No	Parameter	Ci	Satuan	Li	Satuan	Ci/Li	Ci/Li New
1	Bau	Tidak Berbau	–	–	–	–	–
2	pH	6,6	–	6 – 9	–	0,60	0,60
3	Focal Colliform	58	mg/L	100	mg/L	0,58	0,58
4	Nitrate, as N	1,07	mg/L	10	mg/L	0,11	0,11
5	Fosfat	0,17	mg/L	0,2	mg/L	0,85	0,65
6	TSS	14	mg/L	40	mg/L	0,35	0,35
7	DO	3,8	mg/L	6	mg/L	3,20	3,53
8	BOD	3,21	mg/L	2	mg/L	1,61	2,03
9	COD	10,7	mg/L	10	mg/L	1,07	1,15
Sum							8,98
Maximum							3,53
Average							1,12
IP							2,62
Information							Lightly polluted

Source : Calculation Results

Table 18. Results of the Darma Reservoir Pollution Index Calculation Year 2024 March Period (WDM 1)

No	Parameter	Ci	Unit	Li	Ci/Li	Ci/Li New
1	Odor	Odorless	–	–	–	–
2	Turbidity	8,82	NTU	–	–	–
3	Temperature	28,9	ºC	Dev 3	–	–
4	Color	40	Skala TCU	15	2,67	3,13
5	TDS	73	mg/L	1000	0,07	0,07
6	TSS	21	mg/L	40	0,53	0,53
7	Ph	7,38	–	6 – 9	0,08	0,08
8	BOD	16,5	mg/L	2	8,25	5,58
9	COD	35	mg/L	10	3,5	3,72
10	DO	5,5	mg/L	6	1,5	1,88
11	Nitrate, as N	1,3	mg/L	10	0,13	0,13
12	Nitrite, as N	0,04	mg/L	0,06	0,67	0,67
Sum						15,79
Maximum						1,75
Average						5,58
IP						4,14
Information						Lightly polluted

Source : Calculation Results

Table 19. Results of the Darma Reservoir Pollution Index Calculation Year 2024 March Period (WDM 2)

No	Parameter	Ci	Unit	Li	Ci/Li	Ci/Li New
1	Odor	Odorless	–	–	–	–
2	Turbidity	8,07	NTU	–	–	–
3	Temperature	28,7	ºC	Dev 3	–	–
4	Color	38	Skala TCU	15	2,53	3,02
5	TDS	72	mg/L	1000	0,07	0,07
6	TSS	15	mg/L	40	0,38	0,38
7	Ph	7,47	–	6 – 9	0,02	0,02
8	BOD	12,8	mg/L	2	6,4	5,03
9	COD	29	mg/L	10	2,9	3,31
10	DO	4,5	mg/L	6	2,5	2,99
11	Nitrate, as N	1,1	mg/L	10	0,11	0,11
12	Nitrite, as N	0,04	mg/L	0,06	0,67	0,67
Sum						15,59
Maximum						1,73
Average						5,03
IP						3,76
Information						Lightly polluted

Source : Calculation Results

Table 20. Results of the Darma Reservoir Pollution Index Calculation Year 2024 March Period (WDM 3)

No	Parameter	Ci	Unit	Li	Ci/Li	Ci/Li New
1	Odor	Odorless	–	–	–	–
2	Turbidity	7,59	NTU	–	–	–
3	Temperature	28,9	ºC	Dev 3	–	–
4	Color	36	Skala TCU	15	2,40	2,90
5	TDS	74	mg/L	1000	0,07	0,07
6	TSS	9	mg/L	40	0,23	0,23
7	Ph	7,43	–	6 – 9	0,05	0,05
8	BOD	16,1	mg/L	2	8,05	5,53
9	COD	34	mg/L	10	3,4	3,66
10	DO	4,1	mg/L	6	2,9	3,31
11	Nitrate, as N	1,3	mg/L	10	0,13	0,13
12	Nitrite, as N	0,04	mg/L	0,06	0,67	0,67
Sum						16,54
Maximum						1,84
Average						5,53
IP						4,12
Information						Lightly polluted

Source : Calculation Results

From the results of the calculation using the Pollution Index (IP) method, it can be concluded that the results of observations in 2021, 2023 and 2024 can be classified into lightly polluted. This is due to the burden of waste from fish farming activities and household waste as well as waste from agriculture around the waters of the Darma Reservoir, which causes a high pollution index score. However, both observations made in the rainy season such as December and the dry season such as July show the same result, namely, the standard status of water quality in the waters of the Darma Reservoir is lightly polluted (Anas, Jubaedah, & Sudinno, 2017).

The results of, physical and chemical parameters that have been analyzed in 2021, 2023 and 2034 show that the results with the highest pollution levels are in the parameters of Color, COD, BOD and DO. The cause of the high results, of Color, COD and BOD parameters is caused by fish water that settle and leftover feed that is not consumed so that the feed settles and rots so that it causes a lack of oxygen in the waters (Lal & Mogalekar, 2024). It was concluded that if the growth of KJA increases, it can cause the level of pollution to be higher.

Efforts to Control Floating Net Cages

According to Regent Regulation Number 81 of 2020, with a maximum limit of 1,500 plots of Floating Net Cages (Andari & Ella, 2022). However, at this time, the number of floating net cages in the Darma Reservoir based on data from the Fisheries and Agriculture Service of Kuningan Regency has reached 6521 floating net cages. The inundation area in the Darma Reservoir is 309 Ha, where 8.76% of the area is the area of the floating net cage or equivalent to 27 Ha of the reservoir inundation area. With fish production produced at one harvest time, which is 0.75 tons/harvest (Aneta, Umboh, & Sondakh, 2021). Thus, the total fish production in one year is 0.75 tons/harvest x 6521 = 4,890.75 tons/harvest or 14,672.25 tons/year, assuming 3 times the harvest period. Based on the results of these calculations, it can be concluded that the amount of fish production in the Darma Reservoir with the permitted fish production is (14,672.25 – 121,979 tons) = 14,550.27 tons/year or 7,275.13 tons/harvest assuming 3 times the harvest period. From the results of these calculations, the maximum number of Floating Net Cages in the Darma Reservoir is 1011 plots

From the results of the above analysis, it is necessary to implement regulations related to the management and utilization of reservoirs so that the use of the reservoir does not have a negative impact on the waters (Prihadi, Erlania, & Astuti, 2016). And in this case, it is necessary to reduce the number of floating net cages by controlling the number of floating net cages in the Darma Reservoir and periodically transferring them for fish cultivation on land (Aquaculture). In addition, the feeding system for fish needs to be considered again because feeding fish in a full-fledged manner (Ad libitum) also has a negative impact on reservoir waters. Feed management should be adequate (satition) where the feeding is based on the age of the fish and the type of feed used.

CONCLUSION

From the results of research and calculations that have been carried out, it can be concluded that the results of calculations using the Pollution Index (IP) method in 2021, 2023 and 2024 show that the status of water quality standards in Darma Reservoir is in the lightly polluted category. The results of calculations using the Pollution Index (IP) method in 2021 carried out at three observation points, namely WDM 1, WDM 2 and WDM 3 show IP scores ranging from 2.44 to 3.06. The results of calculations using the Pollution Index (IP) method in 2023 in the July period (dry season) were 3.01 - 3.27 while in December the IP score ranged from 2.62 - 3.22. The results of calculations using the Pollution Index (IP) method in 2024 in March and carried out at three observation points, namely WDM 1, WDM 2 and WDM 3, showed that the IP score ranged from 3.76 to 4.14.

From the results of the analysis that has been carried out from the three sampling points, both present and absent, the three floating net cages are included in the depth of light pollution. It can be concluded that high rainfall (rainy season) or drought does not affect the level of pollution status in Darma Reservoir. Of the physical parameters that have been tested, the color parameter of the three sampling station points has exceeded the maximum limit of class I according to Government Regulation Number 22 of 2021. For the chemical parameters that have been tested, the results of several parameters that exceed the maximum limit of class I water quality standards according to Government Regulation Number 22 of 2021 such as; Biological Oxygen Demand (BOD) parameters and Chemical Oxygen Demand (COD) and Dissolved Oxygen (DO) parameters. Efforts that must be made to reduce the number of floating net cages (KJA) that are experiencing a continuous increase are that the relevant government must make clear regulations regarding policies and utilization of the Darma Reservoir as well as licensing procedures for the existence of floating net cages (KJA). In addition, in the process of controlling KJA in Darma Reservoir, it must pay attention to the economic aspects of the surrounding community, namely by educating and socializing about cultivation on land, also known as aquaculture.

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