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Research paper

Environmental carrying capacity review in cengklik reservoir

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Abstract

Reservoir is a body of water that is formed or modified by humans by damming the river for a particular purpose and can be controlled in its use. Cengklik Reservoir besides its main function as irrigation facilities covering an area of 1,578 ha, is also used for tourism activities and aquaculture. However, on December 29th, 2015 many of the fish in the reservoir died. Cultivated fish died suspected to be caused poisoning by reservoir water that contaminated with waste. This study aims to examine the contamination conditions of the current Cengklik Reservoir and how the reservoir zonation for carrying capacity of the growing floating net cage cultivation. This study was conducted using descriptive analysis method based on the results of qualitative and quantitative tests of primary data in the form of water quality of Cengklik Reservoir. The method of research conducted through 4 stages namely preparation, data collection, data analysis, analysis of results discussion and conclusion. It is expected that the results of this study can be used as a review of Reservoir zonation management and the handling of contaminated reservoir problems.

Keywords: *Cengklik Reservoir; Reservoir Zonation; Floating Net Cage.*

1. Introduction

Cengklik Reservoir is located in Ngargorejo Village, Ngemplak Sub district, Boyolali Regency, Central Java Province wherein originally (during the Dutch East Indies Government in 1923) was built to meet the needs of industrial water of Colo Madu Sugar Factory, but starting in 1998 the utilization of its water has been developed for irrigation purposes by increasing the water suppletion from Kali Pepe by constructing the Watuleter Weir along with its suppletion channel, with an effective volume of 9,773 million m^3 and inundation area 10,69 km^2 [1].
In addition to the main functions as irrigation facilities covering an area of 1.578 ha, Cengklik Reservoir is also used for tourism activities and aquaculture. However, on December 29th, 2015, many of the fish in the reservoir died suspected as a result of poisoning by reservoir water that contaminated with waste [2] [3]. According to Maryanto, Head of the Fish Cultivation Group of Floating Net Cage at Ngargorejo Village Ngemplak Boyolali, pollution of the reservoir water is caused by the excessive use of chemical fertilizers from farmers' paddy fields which are then carried by the rainwater to the reservoir. So, it can be suspected that the fish in the reservoir died due to lack of oxygen. The problem of eutrophication is the main cause of decreasing the quality of water, thus disrupting its allotment, so that the mass mortality of fish can occur due to decreased water quality as well as less attention to the bearing capacity of the waters.
Based on the above problems it is very important to examine the contamination condition of the current Cengklik Reservoir and how the reservoir zonation for carrying capacity of the growing floating net cage cultivation.

2. Literature review

Eutrophication is a process of enriching the nutrients in a waters caused by an increase in the nutrients intake that cause eutrophication of N and P which trigger the emergence of ecosystem changes that characterized by an abundance of algae species and aquatic macrophytes [4]. Nutrient as the cause of eutrophication in lakes and reservoirs can come from 2 sources, namely from watershed and from the waters of the reservoir itself. Pollutants in the form of nutrients entering the reservoir through runoff. Runoff that passes through residential areas and agricultural contain high phosphorus as a result of increased use of agricultural fertilizers that can be the cause of eutrophication in rivers and reservoirs [5].

3. Material and methods

Sumitomo and Nemerow (1970) (in Attachment II, the decree of the Minister of Environment of the Republic of Indonesia No.115 Year 2003 [6]), proposes an index relating to a significant contaminant compound for an allotment/ allocation. This index is expressed as the Pollution Index (PI) which is used to determine the level of relative pollution to the allowable water quality parameters. This index has a different concept with the Water Quality Index. The Pollution Index is determined for an allotment, then it can be developed for some allotment for all parts of the water body or part of a river.
Water quality management on the basis of PI can provide input to decision makers in order to assess the quality of water bodies for an allotment and take measures to improve quality in case of quality deterioration due to the presence of pollutant compounds.

Meanwhile based on Government Regulation (PP) No 82 Year 2001 in clause 8, the water quality classification scheme as follows:

Table 1: Classification of Water Allotment Quality Based on Water Quality Classification

Water Quality	Drinking Water	Water Recreation Facility	Farming	Planting
Class 1	√	√	√	√
Class 2	X	√	√	√
Class 3	X	X	√	√
Class 4	X	X	x	√
Information :				
√ allowable				
x not allowable				

Meanwhile the Status of Pollution based on Pollution Index value is as follows (The Decree of Environment Minister No. 115 Year 2003) [6]

$0 \leq PI \leq 1,0$: Meet the standard of quality (good condition)
$1,0 < PI \leq 5,0$: Lightly Polluted
$5,0 < PI \leq 10$: Medium Polluted
$PI > 10$: Highly Polluted

This study was conducted using descriptive analysis method based on the results of qualitative and quantitative tests of primary data in the form of water quality of Cengklik Reservoir. The method of research conducted through 4 stages namely: preparation, data collection, data analysis, results discussion and conclusion.

Sampling in reservoirs is intended to assess the allocation of pollutant loads which enter into reservoirs derived from human activities in water catchment areas. The main parameters measured are the concentration of TP and TN as well as river flow/ discharge. The sampling sites are listed in Table 2.

Table 2: Coordinate of Sampling Points in Reservoir

No	Sampling location	Coordinate	Depth (m)
1	Inlet 1	S 07°29'54,77" E 110°43'29,45"	-
2	Inlet 2	S 07°29'58,61" E 110°43'38,13"	-
3	Reservoir	S 07°30'9,73" E 110°43'31,71"	0,94
4	Reservoir	S 07°30'21,45" E 110°43'23,13"	0,90
5	Reservoir	S 07°30'28,55" E 110°43'30,39"	1,50
6	Reservoir	S 07°30'41,68" E 110°43'33,81"	2,90
7	Reservoir	S 07°30'45,11" E 110°43'56,39"	4,40
8	Near Outlet	S 07°31'0,55" E 110°43'57,65"	4,69
9	Near Outlet	S 07°31'0,71" E 110°43'47,4"	1,97
10	Reservoir	S 07°30'54,28" E 110°43'38,99"	0,30

4. Result of study and discussion

4.1. Hydrology of cengklik reservoir watershed

Based on the hydrological conditions, the river network in Cengklik reservoir is continuous from upstream to downstream area, unify and ended into the Cengklik Reservoir structure by forming a drainage pattern resembling the shape of branch of twig tree (dendritic pattern). The pattern when associated with the drainage system can accelerate the movement of water runoff and facilitate the occurrence of soil erosion in the Cengklik reservoir watershed within an area of 10, 96 km^2. There are several inflow other than rain water that goes to Cengklik Reservoir such as Kali Senting 1 and Kali Senting 2 which is located in the northern of Cengklik Reservoir. The flow of Kali Senting 1 and 2 is met become one before entering the reservoir, with a normal discharge of about 200 liters/sec. Then the flow of Kali Njati 1 and Kali Njati 2 entering the reservoir with a discharge of about 250 liters/sec. Another inflow comes from the suppletion of Kali Botak Weir which is flowed through the regulatory gates to the reservoir.

4.1.1. Regional geology

Based on the geological map of the Central Java Sheet, the geology of the Cengklik Watershed is categorized into the formation of Q_{hv} (Holocene volcanic) namely: Holocene Volcano Rock consisting of various erupted rocks of several strato volcanoes, in the form of volcanic breccia, agglomerate, volcanic mudflow, lava, tuff, lapilli and bomb. Generally composed andesite to basalt, volcano eruption result of: Ciremai, Slamet, Sundoro, Sumbing, Jembangan, Merapi, Tidar, Dieng, Merbabu and Lawu Mountain. This formation was aged during the quarter times composed by volcanic arcs from the central volcano lanes [7].

4.1.2. Land use

Land use of water catchment area in the Cengklik reservoir has been dominated by settlements (60.78%), the remaining is rice fields and reservoir water. From the total area of 1.093,26 ha seen that the area of settlement is 664, 47 ha, while the rice field area is 299, 27 ha. Seeing the dominance of land use by settlements is predicted that the pollution load in the reservoir is quite large.

Fig. 1: Sampling Location Scheme.

4.2. Test result of reservoir water quality

The water quality data used in this study was obtained from the results of the sample tests taken in July 2016 as shown in Table 3.

4.3. Analysis of water quality status based on value of pollution index

Based on the analysis results in Table 4 below, it can be seen that the condition of the cengklik reservoir has been in the category of highly and medium polluted for water quality class I and class II, it means that the surface water condition of Cengklik Reservoir is not feasible for the consumption of raw water or drinking water, because there are some pollution weighing factors such as BOD, COD, TSS, Total Coliform, Fat Oil content, Lead/ Pb content, Manganese, Sulfide, Nitrite and Phospat, all parameters above the threshold of class I and class II. Even from data analysis of 2014, 2015 and 2016, water quality based on Class I quality status is highly polluted between 75 - 95%, the remain is medium polluted status and no lightly polluted status for Class I. Whereas for Class II Status, the Highly Polluted Status between 50 - 60% and the rest is medium polluted. Meanwhile based on Class IV status there is a fulfilled category (point P10 near main dam), lightly polluted, medium polluted and highly polluted (point P6 in the middle of the reservoir).

Table 3: Recapitulation of Water Quality Test Result of Cengklik Reservoir in July 2016

RECAPITULATION OF WATER QUALITY TEST RESULT OF CENGKLIK RESERVOIR IN JULY 2016

Nu	Parameter	Unit	Test Method	maximum level	P3	P4	P5	P6	P7	P8	P9	P10
					7°30'9,73"S	7°30'21,45"S	7°30'28,55"S	7°30'41,68"S	7°30'45,11"S	7°31'0,55"S	7°31'0,71"S	7°30'54,28"S
					110°43'31,71"T	110°43'23,13"T	110°43'30,39"T	110°43'33,81"T	110°43'56,39"T	110°43'57,65"T	110°43'47,40"T	110°43'38,99"T
1	Temperature	°C			28.24	29.14	31.08	29.35	30.12	30.42	30.03	31.10
2	Ph		PP no 82 Tahun 2001	6-9	7.29	7.49	7.85	7.18	7.65	6.85	8.10	8.10
3	Dissolved Residue	mg/L TDS	SNI 06 - 6989.27 - 2005	1000	80	79	78	76	73	71	74	75
4	Suspended Residue *	mg/L TSS	SNI 06 - 6989.3 - 2004	50	82	160	31	80	75	40	70	90
5	DO	mg/L OT	SNI 06 - 6989.14 - 2004	4	6,3	4,6	5,0	4,4	6,0	4,9	4,9	5,0
6	Boron	mg/L B	SNI 06 - 2481 - 1991	1	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001
7	Nitrate	mg/L NO_3	SNI 06 - 2480 - 1991	10	0,5	0,4	0,3	0,3	0,2	0,6	0,6	0,7
8	Nitrite*	mg/L NO_2	SNI 06 - 6989.9 - 2004	0,06	0,04	0,03	0,02	0,02	0,01	0,02	0,03	0,06
9	Ammonia	mg/L NH_3	Metode Hach	(-)	0,27	0,43	0,31	0,23	0,22	0,16	0,20	0,34
10	Phospate*	mg/L PO_4	SNI 06 - 6989.31 - 2005	0,2	0,003	0,005	0,01	0,004	≤ 0,0001	≤ 0,0001	≤ 0,001	0,006
11	Chloride*	mg/L Cl	SNI 6989.19 : 2009	(-)	8,2	7,8	7,8	7,8	7,3	7,3	7,3	7,8
12	Iron *	mg/L Fe	SNI 6989.4 : 2009	(-)	0,3	0,6	0,6	0,6	0,2	0,4	0,5	1,4
13	Manganese *	mg/L Mn	SNI 6989.5 : 2009	(-)	0,6	0,2	0,02	0,1	0,1	0,1	0,2	0,4
14	Natrium	mg/L Na	SNI 06 - 2428 - 1991	(-)	5,3	5,0	5,0	5,0	4,7	4,7	4,7	5,0
15	COD*	mg/L KOK	SNI 6989.2 : 2009	25	17,5	14,1	22,0	23,7	24,7	19,0	17,4	18,1
16	BOD *	mg/L KOB	SNI 6989.72 : 2009	3	10,9	6,8	11,0	11,4	11,7	9,0	10,3	11,0
17	Detergent *	µg/L MBAS	SNI 06 - 6989.51 - 2005	200	27,1	91,2	222,6	164,6	88,7	222,4	87,6	95,4
18	Free Chlorin	mg/L CL_2	Metode Hach	0,03	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001
19	Oil & Fats	µg/L M & L	SNI 06 - 6989.10 : 2004	1000	3000	3000	1000	2000	2000	2000	2000	2000
20	Permanganate value *	mg/L $KMnO_4$	SNI 06 - 6989.22 - 2005	(-)	23,3	23,6	22,1	22,4	22,0	22,7	21,8	23,6
21	Flouride	mg/L F	SNI 06 - 2482 - 1991	1,5	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001	≤ 0,001
22	Sulfide	mg/L S	Metode Hach	0,002	0,035	0,032	0,028	0,029	0,027	0,026	0,030	0,053
23	Sulphate *	mg/L SO_4	SNI 6989.20 : 2009	(-)	4,8	10,0	2,7	2,3	1,6	1,1	2,0	5,3
24	Cyanide	mg/L CN	Metode Hach	0,02	0,011	0,007	0,008	0,007	0,011	0,006	0,008	0,011
25	Pb	mg/L Pb	SNI 06 - 6989.46 : 2005	0,03	0,08	0,08	0,04	0,04	0,03	0,1	0,005	0,04
26	Copper	mg/L Cu	SNI 06 - 6989.6 - 2004	0,02	0,01	0,0005	0,03	0,02	0,02	0,01	0,01	0,01
27	Nickel	mg/L Ni	SNI 06 - 2520 - 1991	(-)	0,08	0,1	0,1	0,09	0,08	0,07	0,06	0,05
28	Total Chrome	mg/L Cr	SNI 06 - 6989.17 - 2004	(-)	0,03	0,01	0,02	0,07	0,03	0,01	0,06	0,02
29	Heksavalen Chrome	mg/L Cr^{6+}	SNI 6989.71 : 2009	0,05	≤ 0,0001	0,05	≤ 0,0001	≤ 0,0001	≤ 0,0001	≤ 0,0001	0,03	0,01
30	Total Coliform	JPT/100 mL	Metode MPN	5000	$2,8 \times 10^4$	$9,3 \times 10^4$	$7,5 \times 10^4$	$2,4 \times 10^5$	$1,5 \times 10^4$	9×10^3	$7,5 \times 10^4$	3×10^3

Note :
The Maximum Level is based on Attachment of PP No.82 Year 2001,Water Quality Criteria Class II
Parameters is accordance to the request
(-) : Not Requaried
* : Parameters already accredited

Table 4: Analysis Result of Total Pollution Index (PI) and Water Quality Status

No	Code	Total of Polluted Index (IP)				Category			
		Class I	Class II	Class III	Class IV	Class I	Class II	Class III	Class IV
1	**P1**	DRY (No water in reservoir)							
2	**P2**	DRY (No water in reservoir)							
3	**P3**	12.6927	6.988	4.7361	4.3741	Highly Polluted	Medium Polluted	Lightly Polluted	Lightly Polluted
4	**P4**	16.8841	11.1821	8.6788	8.6276	Highly Polluted	Highly Polluted	Medium Polluted	Medium Polluted
5	**P5**	16.0831	10.3693	8.6789	7.946	Highly Polluted	Highly Polluted	Medium Polluted	Medium Polluted
6	**P6**	20.2141	14.5146	12.0314	12.0545	Highly Polluted	Highly Polluted	Highly Polluted	Highly Polluted
7	**P7**	10.4311	5.6541	12.0539	2.4508	Highly Polluted	Medium Polluted	Highly Polluted	Lightly Polluted
8	**P8**	8.6236	5.127	5.0605	1.2414	Medium Polluted	Medium Polluted	Medium Polluted	Lightly Polluted
9	**P9**	16.0961	10.3771	3.2264	7.8692	Highly Polluted	Highly Polluted	Lightly Polluted	Medium Polluted
10	**P10**	7.0279	5.4562	4.2676	0.6909	Medium Polluted	Medium Polluted	Lightly Polluted	Qualify

4.4. Analysis of the condition of some reservoir water quality parameters

4.3.1. Total coliform

The amount of total coliform content above the maximum threshold of 5000 JML/100 mL shows the density of settlements around the reservoir contributes to domestic waste pollution to the reservoir body. Measurement data of total Coliform in Cengklik Reservoir ranges between 15.000 JML/100mL even in July 2016 measurement reaches 93.000 JML/100mL at point P4 and 240.000 JML/100mL at point P6. The content of this coliform bacteria indicates dense settlements around reservoir bodies and in upstream of watersheds, and poor public sanitation. The possibility of the number of public sanitation facilities is still minimum, and many residents who dispose of sewage into the river body enter to the reservoir.

4.3.2. Nitrite

In addition to the high coliform bacteria, nitrite levels in the Cengklik reservoir had almost reached the maximum threshold of 0.06 mg/L NO_2. Nitrites are natural inorganic ions that are part of a cycle of Nitrogen element in nature. The process starts from a substance/material containing Nitrogen by micro-organisms converted to Ammonia (NH4), then it will oxidize to Nitrite (NO_2^-). Nitrite chemical bond is unstable then Nitrite will oxidize again become Nitrate (NO_3^-) so that the Nitrate ion element is most common in surface and underground water. The source of Nitrogen element can be derived from mineral dissolution in rocks and soils, fertilizers on agricultural land, waste generated by human activities. Nitrates are formed from nitrite acid derived from ammonia through the catalytic oxidation process. Nitrite is also the result of the metabolism of the nitrogen cycle. Medium form of nitrification and denitrification. Nitrates and nitrites are components that contain nitrogen binding to oxygen atoms, nitrates bind three oxygen atoms while nitrite binds two oxygen atoms. The increased nitrite content can also be caused by the rest of the fish feed that is not consumed by the fish wherein at the location Cengklik reservoir widely spread the Floating Net.

4.3.3. BOD and COD

The increasing of the COD and BOD values above the threshold also indicates the level of pollution. BOD (Biochemical Oxygen Demand) means the need for biochemical oxygen which indicates the amount of oxygen used in the oxidation reaction by bacteria. So the more organic matter in the water, the bigger the BOD meanwhile the DO will be lower [13]. Clean water has the BOD less than 1 mg/l or 1ppm, if its BOD above 3ppm, the water is said to be polluted. COD (Chemical Oxygen Demand) is the same as BOD, which shows the amount of oxygen used in chemical reactions by bacteria. The increasing of the organic materials in reservoir body is one of the cause of the increasing levels of BOD and COD.

4.3.4. Metal content

In Cengklik Reservoir, Copper, Lead, Iron, Cyanide and Sulfide metal content are also quite high. From the July 2016 measurement results, these metal content are above the standard quality threshold. Lead or P_b metal is a type of soft-blackish brown colored metal and easily purified. P_b metal is more widespread than most other toxic metals and is naturally present in rocks and layers of the earth's crust [8]. Lead is widely used in industry as fuel additives, and pigments in paints that cause an increase in P_b levels in the environment. Naturally, P_b enters the water body through crystallizing P_b in the air with the help of rainwater and the corrosification process of mineral rocks. The main source of metal infusion according to Wittman (1979) in Connel, D. W. and Miller, G. J. (1995) [9] is derived from mining activities, household waste water, sewage and industrial waste. Rocks damage, soil formation, human activity and increased use of agricultural fertilizers also lead to increased concentrations of metal pollutants in reservoirs [10]. For the interests of aquatic biota, P_b levels of 0.1-0.2 ppm can cause poisoning in certain types of fish (Rodier in Thamzil et al., 1980 [11]) and at levels of 188 ppm can kill fish. Possible indications of P_b in the Cengklik reservoir are suspected coming from residues of agricultural activity pesticides containing P_b metal then enter through infiltration into the soil. Liquid pesticides are made by dissolving the active ingredients with xylene, naphthalene and kerosene. Residues of P_b heavy metals in addition coming from pesticides may also be derived from phosphate fertilizer residues. The presence of lead can also be sourced from fuel which containing lead in motor boats as a means of transportation around the Cengklik reservoir.

Fig. 2: The Growth of Water Hyacinth in Front of the Maindam of Cengklik Reservoir.

4.5. Analysis of the floating net cages fish cultivation carrying capacity in cengklik reservoir

The types of fish cultivated in Cengklik Reservoir are tilapia and catfish. These fish are generally cultivated with floating net cage system/ sistem keramba jaring apung (KJA). The size and shape of KJA is generally 6m x 6m and the net height is between 4 - 5 m per plot. In Cengklik Reservoir it is rare to use multilevel nets given the relatively shallow reservoir water depth, that is at the condition of the water level around +139.00 wherein the depth elevation of the reservoir water 5 meters in the deepest trough. According to information from local fishermen, generally for cage a fisherman who has a number of cages 12 boxes (one box = 6m x 6m) then it takes about 55 sacks of fishmeal (1 sack= 30 kg) to meet the needs of feed up to 3 months (120 days) maintenance period. The average in one year can spread fish seeds 3 times with varied yields.
The carrying capacity of the Cengklik Reservoir towards Floating Net Cages/ KJA cultivation is calculated based on morphological and hydrological characteristics and the quality of the reservoir water, as well as the potential of fish feed waste load. Calculation of carrying capacity using the model as described based on the Ministry of Environment's Guidelines. The Phosphorus (P) element is a key parameter in modeling and calculating the reservoir carrying capacity for waste entering the reservoir [4]. The eutroph status standard for the total P element content is 100 ug/l or mg/m^3. Because the source of the waste load is not only from Floating Net Cages, but also from other sources, it is necessary to determine the allocation of the allowable total P waste load, for example 30 mg /m^3 (30% of the waste load P that meets the eutrophic standard, hereinafter referred to as P30) or 50 mg/m3 (50% of the P waste load is hereinafter referred to as P50).

Table 5: Characteristics of the Reservoir and Carrying Capacity of Floating Net Cages/ KJA Fish Cultivation

NO	MORPHOMETRY OF RESERVOIR AND CARRYING CAPACITY OF KJA	UNIT	Floating Net Cages (KJA)			Note
			ALTERNATIVE-1	ALTERNATIVE-2	ALTERNATIVE-3	
1	MORPHOMETRY OF RESERVOIR					
	Elevation of Reservoir Water Level	m	142.6	138.64	138.64	
	Area (A)	ha	286.55	192.32	192.32	
	Volume (V)	Million m^3	9.36	2.58	2.58	
	Average Depth (Z)	m	8.6	4.64	4.64	
	Outflow (Qo)	m^3/sec	0.3917	0.3917	0.28125	
	Total Outflow (Qo)	Million m^3/tahun	12.35	12.35	8.87	
	Flushing rate (ρ)	$tahun^{-1}$	1.32	4.79	3.44	
	Residence time of water (Tw)	tahun	0.76	0.21	0.29	
2	CARRYING CAPACITY OF KJA					
	Total P Fish, P_{std}	mg/m^3	30	30	30	
	R, Proportion P Dissolved		0.54	0.38	0.42	
	R		0.79	0.72	0.74	
	L, Capacity P/Area	gr P/m^2 tahun	1.636	2.380	1.827	
	Waste Load, La-Fish	ton P/tahun	4.688	4.577	3.513	
	PLI , P - Fish Waste	Kg P/ton fish	21.500	21.500	21.500	
	Fish Carrying Capacity, Ddik	ton fish/tahun	218.06	212.90	163.41	**Field data = 57,08 ton**
	FCR	ton feed/ton fish	2.250	2.250	2.250	Normal Condition Assumption
	Feed Carrying Capacity, DDpk	ton feed/tahun	490.64	479.03	367.68	**Field data = 673,2 ton**
	Carrying Capacity - KJA	Plot	770.367	752.133	577.303	**filed data = 1057 plot**
	Total of Fishermen (10 plots/person)	Person	77	75	58	

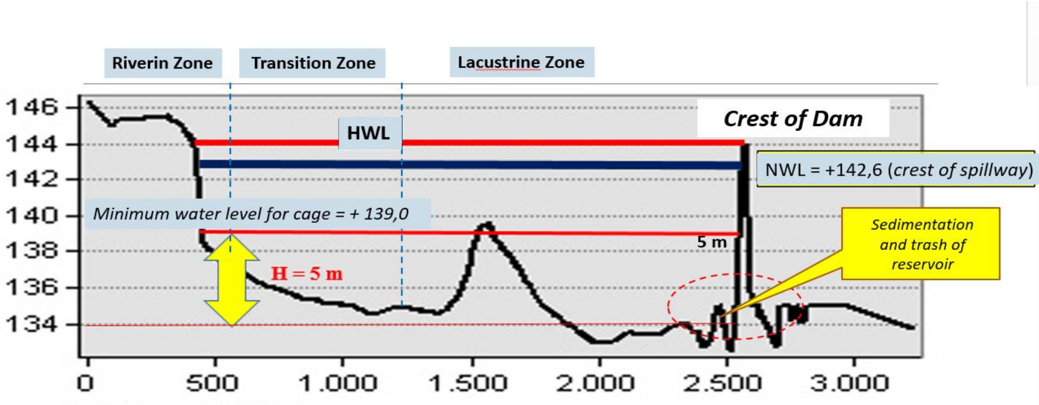

Fig. 3: Reservoir Zonation and Minimum Elevation of Floating Net Cages/ KJA Cultivation.

The amount of fish production and the amount of feed consumption in the Cengklik Reservoir turned out exceeding the carrying capacity of the Floating Net Cages/ KJA aquaculture with both alternatives. The use of fish feed 673.2 tons of feed/year far exceeds the feed carrying capacity/ daya dukung pakan (DDPk) 490.64 tons of feed/year for alternative 1 (Elevation of Reservoir Water Level in normal condition NWL = + 142,6), and 470,3 of feed/year for alternative 2 (minimum water level of cages + 138,6) and 367,68 tons of feed/year for alternative 3 (water discharge conditions in dry years). The number of KJA plots currently also exceeds the carrying capacity of the Floating Net Cages (DDKJA) which should be 770,37 plots (alternative 1), 752,13 plots (alternative 2), and 577, 30 (alternative 3) but in reality in 2016 the number of plots was 1057 with the number of fishermen as cage owners around 136 people. From the results of the interview on the excellent condition the fishermen in Cengklik Reservoir can harvest fish about 1 ton per fisherman (average 12 cages boxes) for one harvest season. But in bad conditions, it can only harvest about 2 quintals of fish. Meanwhile, according to Mr Maryanto (Head of KJA Ngargorejo which has 10 cages) can harvest about 6 quintals/month in good condition while the worst is about 3 quintals/month [12].

4.6. Geostatistical analyst for water quality distribution

Statistical analysis in this study is used to conduct a cluster or pollution index zoning. There are several methods that can be used to interpolate such as Trend, Spline, Inverse Distance Weighted (IDW) and Kriging. Each of these methods will give different interpolation results. In this study, focusing on the search point value of the model output using the IDW method because this method produces satisfactory interpolation and the results are mapped using GIS using ArcGIS 10.3 assistive software by utilizing Geostatistical analyst extension.

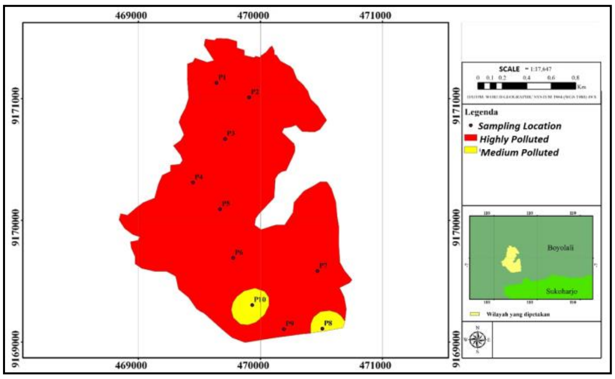

Fig. 4: Zonation Map of Pollution Index Class 1.

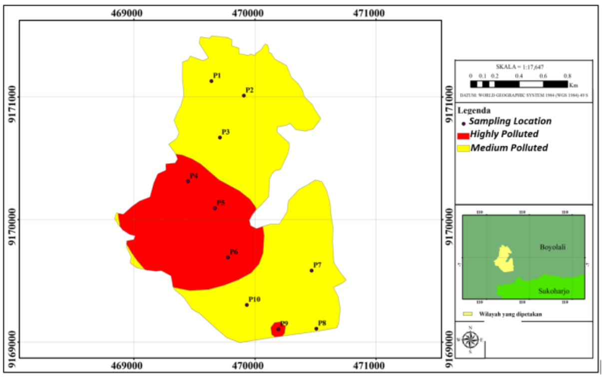

Fig. 5: Zonation Map of Pollution Index Class II.

Error test from interpolation results to test or find out the level of error of an analysis method needs to be done so that the conclusions produced have a level of trust. One of the test tools is the root mean square method. In accordance with the meaning, RMS or root mean square is the root of the average value of a squared function. RMS calculated by IDW toolbox, which the first to do is to square the function, then calculate the average value by integrating from interval a to interval b, and then made root the result of the value the average obtained. The results of testing the error rate of each IDW model on several parameters are as follows:

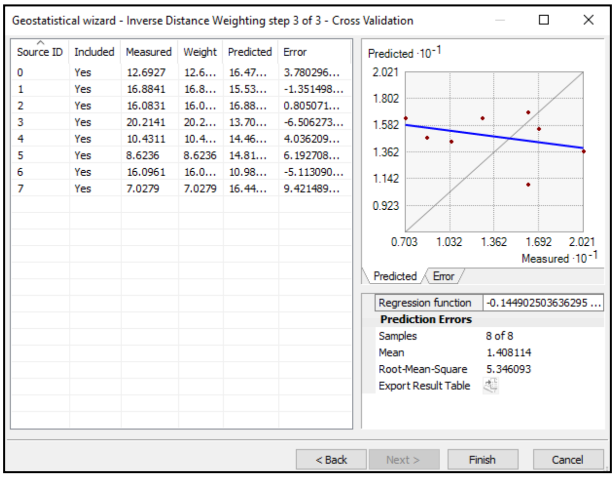

Fig. 6: Geostatistical Analysis on Pollution Index-Class I.

Table 6: Values of Mean and RMS from the Geostatistical Analysis of the IDW Method

Num	Parameter	Mean	RMS value
1	Pollution Index Class I	1,4081	5,3461
2	Pollution Index Class II	1,2198	4,0325
3	Pollution Index Class III	1,1862	3,8468
4	Pollution Index Class IV	2,5218	4,9788

5. Conclusion and recommendation

5.1. Conclusion

From the results of this study, some conclusions can be drawn as follows:

1) The current water quality of the Cengklik Reservoir maximum qualified the class 3 quality so that the allotment is suitable for freshwater fish cultivation, livestock, landscaping and other uses with the same quality requirements. From the results of the water quality test, the existing condition of cengklik reservoir water quality can be categorized as Highly Polluted (Class 1 and Class 2 quality), Light to highly polluted (class 3 quality) and qualified up to Medium (class 4 quality).
2) The weighing factor to this pollution condition comes from outside and inside the reservoir body. Waste from outside the Cengklik Reservoir comes from agricultural, household and industrial fertilizer waste and waste from upstream watersheds while waste from the reservoir body comes from the abundant Floating Net Cages/ KJA fish feed.
3) Pollutants that come from outside the reservoir and very critical is the pollution of Coliform bacteria which exceeds 5 times the threshold of Class 2, this is due to the amount of waste from domestic (septic tank) entering the river and then flowing into the dam body or directly to the dam body. Besides that the other symptoms of increased pollutants is the increase of Nitrite, Nitrate and Phosphate possible from agricultural and domestic waste. The increased levels of BOD and COD in the Cengklik reservoir also indicate high levels of pollution in the reservoir, even the measurement results in 2014 and 2015 already above class II thresholds.

5.2. Recommendation

Zonation of fishery cultivation placement of Floating Net Cages/ Keramba Jaring Apung (KJA) in Reservoir water bodies are as follows:

1) Zonation of Floating Net Cages/ KJA cultivation area should not interfere with the existence and function of the dam. In accordance with the condition of the Cengklik Reservoir water body, the KJA zone should not be located near the reservoir intake and should be more than 250 meters away from the dam axle. The limit of 250 meters from the dam body should be given a floating sign to make it easier to monitor as a prohibition zone for the reservoir operation protected area zone. Cultivation of Floating Net Cages/KJA must not disturb or close the river flow that enters the reservoir (Kali Senting, Kali Njati 1 and Njati 2 or Suppletion Channel of Kali Butak) in order not causing deposition of river mud and silting.
2) Floating net Cages/ KJA cultivation techniques in Cengklik Reservoir are not suitable for stratified/ mulitilevel types, this is because the relatively shallow reservoir depth at NWL conditions with an elevation of + 142.0 m is only obtained the depth of water in the deepest trough of 8 meters. Whereas the cengklik reservoir water level has never overflowed the spillway, and average reservoir water level in the field ranges from + 139,00 elevation or 5 meter water depth which is the minimum depth of fish cultivation with Floating Net Cages/ KJA system.
3) Reducing pollutant materials that enter reservoirs mainly from rivers/trybutaries originating from domestic waste, industry, hospitals, especially those containing B3 waste, and faecal waste that is discharged directly into the river body contains quite high levels of coliform bacteria, by conducting public sanitation programs for the community around the river border, cooperation agencies related to sanitation issues and structuring the river/reservoir border area.
4) Restore the reservoir border zone at least 50 meters from the flood water level/ FWL (elevation + 143,5), provides greent belt protection in border areas and clear marker boundary toward the ownership of reservoir boundary line. In addition, it is necessary to control the growth of place of shop without permit in the body of the dam so that interfere the reservoirs stability, aesthetics and contamination of reservoirs water.
5) The number of Floating Net Cages/ KJA and consumption of fish feed in the Cengklik Reservoir has exceeded the allocation of waste load and reservoir carrying capacity, so the amount must be reduced by a maximum of 770 plots at normal water level conditions (+142,6) while at a low elevation (+ 139.00) a maximum of 577 plots, as well as the location/position settings.

The high consumption of fish food per year further worsens the quality of reservoir water, need an effort to reduce/control the growth of floating net cages. Non-absorbed fish feed increases Nitrate and phosphate levels if allowed would accelerate the eutrofication of the reservoir and uncontrolled algae growth, so the reservoir loses its function due to aesthetics and pollution. In addition, the current ownership of Floating Net Cages/ KJA is mostly unlicensed, so it needs to be regulated.

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