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Evaluation of Tilong Dam Water Quality as a Source of Raw Water, Kupang

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***Abstract*—** *Indonesia's water security will continue to experience difficulties and rapid deterioration without major investments (Piesse, 2016). East Nusa Tenggara (NTT) is one of provinces in Indonesia that is experiencing difficulties in getting water. One of the government's efforts to improve water security was a construction of Tilong Dam in 1999. However, after 20 years of operation, its performance has started to decline causing various water problems, one of which is pollution. The biggest impact felt by surrounding community is temporary cessation of clean water distribution due to a decline in Tilong Dam water quality, which can be seen by changing color of water to cloudy and greenish yellow. This study used primary data; data taken directly in the field in the form of water samples which were then tested in laboratory to determine water quality and trophic level of Tilong Dam. To obtain good results, water sampling followed SNI 03-7016-2004 recommendations on sampling procedure for monitoring water quality. Measurement of water quality status using Storet method at Tilong Dam shows that water quality is classified as Class C or moderately polluted (-26). Additionally, chemical parameter (BOD) is a parameter that most influences decline in water quality at Tilong Dam, but there are also other parameters affecting decline in water quality including pH, total solid, turbidity and total coliform.*

***Keywords*—** *Water Quality, Tilong Dam.*

I. Background

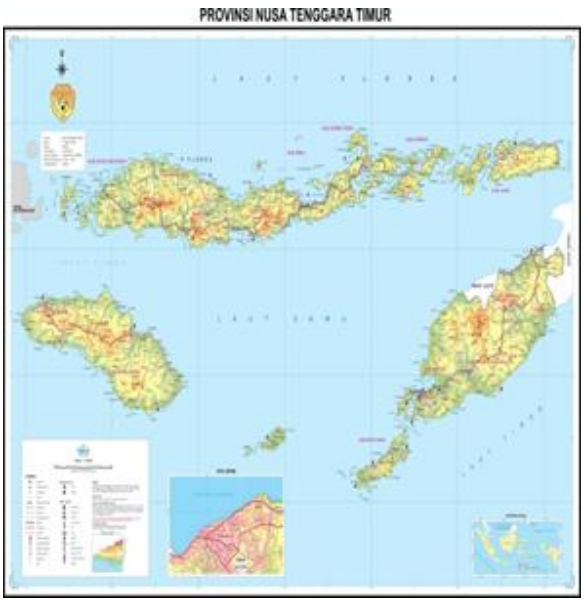
One of main elements for human survival is, in fact, water. Provision of clean water is an essential need that must be fulfilled. Declining water quantity and quality that can meet human needs, as an important factor in determining life and health, is a problem that is frequently experienced today. Indonesia basically has enough water to meet the needs of its population and economy. However, unequal distribution, poor management and inadequate infrastructure make it difficult for people to get water. East Nusa Tenggara (NTT) is one of provinces in Indonesia that is experiencing difficulties in getting water. Its people depend on rainfall and groundwater. During drought, water sources are polluted, leading to an increased incidence of disease (Piesse, 2016).

One of the government's efforts to improve water security was a construction of Tilong Dam in 1999, built in Oelnasi Village, Central Kupang, Kupang, NTT. Tilong Dam is intended to meet the needs of raw water and irrigation water for community with a storage area of 19 million cubic meters. NTT Public Works and Public Housing Office claimed that after 20 years of operation, due to natural factors and human activities, Tilong Dam performance has started to decline causing various water problems such as pollution, eutrophication, lowering dam water level, and water conflicts. The biggest impact felt by surrounding community is temporary cessation of clean water distribution due to a decline in Tilong Dam water quality, which can be seen by changing color of water to cloudy and greenish yellow. Furthermore, natural factors and human activities can also cause eutrophication. Eutrophication process that occurs when input load is too large will result in a decrease in water quality, which will damage life of phytoplankton as main water producer. Besides, input load can also cause sedimentation since it can be in the form of soil particles, etc. which are carried away due to erosion in upstream area. As a result, there will be a reduction in production layer of water area and shorten life of dam.

II. Methods

Research Location

Here is an image showing research location. Tilong Dam is located in Noel Nasi Village, Central Kupang, Kupang, East Nusa Tenggara. Its distance is ±31 kilometers from the city of Kupang.



Data Collection Methods

This study used primary data; data taken directly in the field in the form of water samples which were then tested in laboratory to determine water quality and trophic level of Tilong Dam. To obtain good results, water sampling followed SNI 03-7016-2004 recommendations on sampling procedure for monitoring water quality. There were also secondary data

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including topographic maps, Tilong Dam data, water quality data, discharge data and population data. Here, secondary data were taken from Regional Office of Regional Public Service Agency-Drinking Water Supply System (BLUD-SPAM) of NTT Province, River Basin Organization Nusa Tenggara II (*Kantor Balai Wilayah Sungai Nusa Tenggara II* – henceforth BWS NT II), and NTT Provincial Health Office.

Data Analysis Methods

Data in this study were analyzed using Storet method. Based on Decree of the Minister of Health No. 907 of 2003, mandatory parameters used in Storet method include temperature, TSS, DO, BOD, Ph, NO_2, NO_3, Total Coli.

III. Results And Discussion

Decline of Tilong Dam water quality could be seen directly based on one of characteristics shown and could be observed directly. There was a change in color of its water becoming cloudy and greenish yellow (Figure 1)

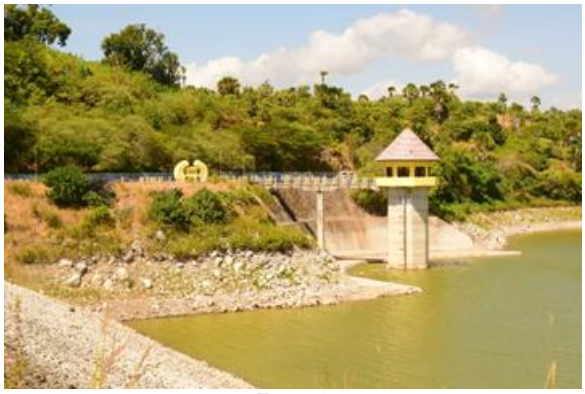

Figure 1

Data obtained from several related agencies were then analyzed by Storet method using 12 parameters to determine which parameters met or exceeded class 1 water quality standard (raw water designation) at Tilong Dam. Based on these results, water quality status could be determined (Table 1).

TABLE 1. Classification of Water Quality Status

No	Class	Condition	Skor	Note
1	Class A	Excellent	0	Meet quality standards
2	Class B	Good	-1 to -10	Lightly polluted
3	Class C	Moderate	-11 to -30	Moderately polluted
4	Class D	Poor	-31	Severely polluted

Source: *Environmental Protection Agency*

Measurement of Storet Method

Results of complete measurement of Tilong Dam water quality status based on Storet method can be seen in Table 2. Based on measurement results, total score was -26, meaning that Tilong Dam Water Quality Status was in C class category or moderately polluted with the most influencing parameter was BOD (Chemical Parameter). In addition to BOD, there were also two other parameters affecting decline in water quality at Tilong Dam, namely COD and E-Coli.

TABLE 2.

Storet Method										
No	**Parameters**	**Unit**	**Quality Standards**	**Measurement Results**						**Total**
				Max	**Score**	**Min**	**Score**	**Average**	**Skor**	
1	Temperature	C	Deviation 3	28.12	-	27.4	-	27.78	-	0
2	pH	-	6-9	8.47	0	8	0	8.27	0	0
3	TSS	mg/L	50	31	0	1.6	0	11.32	0	0
4	DO	mg/L	6	7.42	-	6	-	6.39	-	0
5	BOD	mg/L	2	2.52	-4	2	0	2.24	-12	-16
6	COD	mg/L	10	16.23	-4	9	0	5.046	0	-4
7	Total-N	mg/L	10	0.31	0	0.2	0	0.23	0	0
8	Total-P	mg/L	-	18.55	0	10.21	0	14.79	0	0
9	Turbidity	NTU	-	1.9	0	0.5	0	1.4	0	0
10	Chlorophyll- A	µg/l	15-30	30	0	1.491	0	15.14	0	0
11	E- Coli	CFU/ 100 ml	100	105	-6	60	0	85.4	0	-6
12	Total Coliform	CFU/ 100 ml	1000	987	0	500	0	297.4	0	0
Total Skor										**-26**

Source: Measurement Results, 2020

NSF-WQI Method

National Sanitation Foundation Water Quality Index (NSF-WQI) or water quality index is determined to assess the water quality level of a waters based on 9 parameters: BOD, DO, nitrate, total phosphate, temperature, turbidity, total solid, pH and total Coliform.

TABLE 3. Weighting of Water Quality Parameters

No	Parameters	Weight
1	DO	0.17
2	BOD	0.11
3	Temperature	0.10
4	pH	0.11
5	Nitrate	0.10
6	Total-P	0.10
7	Total Solid	0.07
8	Turbidity	0.08
9	Total Coliform	0.16

Source: Water Quality Index, 2014

Results of measurement of water quality status at Tilong Dam using NSF-WQI method can be seen in Table 4.

Based on measurement results, total Water Quality Index was 51.27, meaning that Water Quality Status of Tilong Dam was included in moderate class water quality status with the most influencing parameter was BOD (Chemical Parameter). Besides BOD, other parameters such as pH, turbidity, total solid and total coliform also affected decline in water quality at Tilong Dam.

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TABLE 4. Measurement of Water Quality Status using NSF-WQI Method

No	Parameters	Unit	Quality Standards	Average Data Measurement Results	Sub Index Value (Q)	Weighting Factor	Sub T
1	DO	mg/L	6	6.39	29.41	0.17	5
2	BOD	mg/L	2	2.24	75	0.11	8.25
3	Temperature	C	Deviation 3	27.78	12	0.1	1.2
4	pH	-	6-9	8.27	74	0.11	8.14
5	Nitrate	mg/L	10	0.23	80	0.1	8
6	Total-P	mg/L	-	14.79	2	0.1	0.2
7	Total Solid	mg/L	50	11.32	82	0.07	5.74
8	Turbidity	NTU	-	1.4	95	0.08	7.6
9	Total Coliform	CFU/ 100 ml	1000	297.4	34	0.16	5.44
					Total =	1.00	51.27
					Water Quality Index =		51.2
					Water Quality Classification =		MODERA

Source: Measurement Results, 2020

Tilong Dam Water Quality

Phosphorus, Nitrogen, Chlorophyll-A and Turbidity are 4 parameters used to determine water quality. This study used data taken from BWS NT II. Data were also obtained from direct sampling at research location as comparative data since there was sediment dredging process underway at Tilong Dam.

Tilong Dam Water Quality (prior to Sediment Dredging)

Data on Phosphorus, Nitrogen, Chlorophyll-A and Turbidity content obtained from BWS NT II in 2020 (prior to sediment dredging) can be seen in Table 5.

TABLE 5. Tilong Dam Water Quality Data

WATER QUALITY DATA 2020					
No	Year	Parameters			
		Total-N (%)	Total-P (mg/m³)	Turbidity	Chlorophyll- A (mg/m³)
1	2020	0.31	18.55	1.9	30

Source: Secondary Data From BWS NT II, 2020

TABLE 6. Total Value of Index Status

Total Value of Index Status					
No	Year	TSI P	TSI Kla	TSI SD	Average TSI
1	2020	46.263	63.966	50.751	53.660

Source: Analysis Results, 2020

Tilong Dam Water Quality (While Sediment Dredging Process was Underway)

Water samples from Tilong Dam taken while sediment dredging process was underway aimed to compare Tilong Dam water quality before sediment dredging was carried out based on data obtained from BWS NT II.

Moreover, water sampling method followed recommended regulations according to SNI-03-7016-2004 on sampling procedure for monitoring water quality. Water sample taken was then taken to NTT Provincial Health Office for examination.

Data and measurement results of Tilong Dam water quality while sediment dredging was underway can be seen in Table 7.

TABLE 7. Tilong Dam Water Quality Data

No	Points	Parameters			
		Total-N (%)	Total-P (mg/m³)	Turbidity	Chlorophyll- A (mg/m³)
1	Inlet	0.35	28.2	1.92	37.51
2	Outlet	0.33	20.23	1.9	34.12

Source: NTT Provincial Health Office

TABLE 8. Total Value of Index Status

No	Points	TSI P	TSI Kla	TSI SD	Average TSI
1	Inlet	52.303	66.157	50.600	56.353
2	Outlet	47.513	65.228	50.751	54.497

Source: Analysis Results, 2021

Based on measurement results using Carlson's method before and while sediment dredging was underway, Tilong Dam was included in mild eutrophic category because it was in values range of 50-60. It can be seen in table of data and data analysis that there was an increase that was not too significant in 4 parameters studied.

Machbub et al., (2003) strongly advocate that eutrophication in lake and dam waters can be identified through several indicators:

1. Decreased dissolved oxygen concentration in hypolimnion zone;
2. Increased nutrients, namely nitrogen and phosphorus, in water bodies;
3. Decreased transparency of waters; and
4. Increased suspended solids, especially those containing organic material.

Referring to this study, decrease in water quality at Tilong Dam could be detected since there was a decrease in brightness/transparency of its water, a change water color becoming cloudy and greenish yellow, as well as levels of nutrients that had started to increase. In fact, condition of waters that have undergone fertilization can make process of managing water used as raw material for drinking water more difficult (Suryono et al., 2008).

Water Pollution Control Strategies

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Aspects	Alternatives	Description
Planning Management and Technology Approach	River Class Segmentation Designation	Designating water class segmentation of watershed around Tilong Dam based on capacity and pollution load
	Supervision and coaching	Providing supervision and coaching for people in charge of businesses whose activities have potential to pollute waters around Tilong Dam
	Integration of water pollution control in spatial planning	Integrating water pollution control in spatial planning through preparation of master plan for dam water resources management
	Technology approach and a comprehensive study of water resources	Utilizing appropriate technology to minimize and control pollution by utilizing 3R principle (reuse, recycling, recovery), systematic monitoring programs on quantity, quality and use of water resources
Social, Economic and Institutional	Inter-agency coordination	Improving inter-agency coordination related to controlling water pollution in licensing process
	Provision of data and information	Providing accurate and up to date data and information on condition of river water quality as references in the next Water Pollution Control program
	Capacity building programs that build expertise on water issues	Increasing capacity of knowledge and expertise about water of BWS staff/water resources stakeholders who can identify and implement solutions technically and can enforce rule of law
	Development of economic value of water and internalization of environmental costs	Involving private parties related to economic mechanisms and designed to be incentivized by adjusting environmental laws; development of water quality management based on cost-benefit analysis
Ecology and Human Health	Increased community participation	Increasing role of community in efforts to control water pollution through socialization and counseling regarding sanitation and use of fertilizers, pesticides and detergents
	Development of a community sanitation system	Developing community sanitation system in the form of MCK (bath-wash-toilet) system, MCK plus, and Communal Wastewater Treatment Plant (IPAL)
	Vegetation planting along riverbanks	Planting vegetation along riverbanks that functions as a green line and prevents occurrence of river bank landslides, keeps river flow in natural conditions, as a filter for nutrients contained in flow of water entering the river, and can increase dissolved oxygen content in river water
	Conservation of water catchment areas in upstream area	Conserving water catchment areas in forest areas in upstream area to maintain quality and quantity of water resources

Source: Primary Data, 2021

IV. Conclusion

Measurement of water quality status using Storet method at Tilong Dam shows that water quality is classified as Class C or moderately polluted (-26). Besides, water quality status of Tilong Dam calculated using NSF-WQI Method obtained total final score of 51.27 indicating that water quality is in moderately polluted category. Chemical parameter (BOD) is a parameter that most influences decline in water quality at Tilong Dam, but there are also other parameters affecting decline in water quality including pH, total solid, turbidity and total coliform.

More importantly, community activities such as bathing, washing, and latrines in upstream area are main factors for decline in water quality at Tilong Dam. In addition, in terms of agricultural sector, use of fertilizers and pesticides which are not in accordance with dosage as well as the existence of drainage of fertilizers and pesticides also affects decline in water quality at Tilong Dam.

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