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Investigation of water quality in a tilapia (*Oreochromis niloticus*) culture area with embedded net cages in Warkuk Ranau Selatan District, Indonesia

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Abstract. The waters of Lake Ranau, Warkuk Ranau Selatan District, Indonesia, are an area suitable for the development of tilapia aquaculture using embedded net cages. Organic waste generated from aquaculture activities can decrease the quality of lake waters. The purpose of this study was to analyze the quality of the waters of Lake Ranau in Warkuk Ranau Selatan District. This research was conducted in January 2020. Analysis of water quality data used the Pollution Index method. The results showed that water quality parameters could be included in the good category, except for ammonia concentration at several stations, where values exceeded the quality standard. This is likely to occur because of excessive fish farming and settlement activities around the waters. Overall, the waters of Lake Ranau in the Warkuk Ranau Selatan District are still viable for tilapia aquaculture activities using embedded net cages.

Key Words: aquaculture, Lake Ranau, organic, viable parameters.

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Introduction. Lake Ranau is one of the natural resources used in fish farming. It has long been used by local fishing communities in making a living (Makmur et al 2017). Lake Ranau is a place for Nile tilapia (*Oreochromis niloticus*) aquaculture using embedded net cages (KJT) by the communities near the lake. Communities in the region use KJT aquaculture activities as permanent or side livelihoods.

Based on the 2016 Data of Fishery Production in Warkuk Ranau Selatan District, 322 units of KJT produced 716 tons of tilapia. Fish farming with the KJT system greatly helps the economy and the welfare of the community. However, aquaculture production activities must still pay attention to the preservation of resources and the environment to create a sustainable cultivation area.

Organic waste generated from fish farming activities can decrease the quality of lake waters. The farming waste disperses into the waters, increasing nutrient levels and polluting the environment 5Erlania 2010; Urbasa et al 2015; Tokah et al 2017). This is in accordance with Hidayah et al (2014), Muhaemi et al (2015), and Syawal et al (2016), that the water quality derivation is caused by various activities of the lakeshore communities and entrepreneurs.

The research results of Saputra et al (2017) also show the high values of ammonia, nitrate, and sulfide caused by the accumulation of several pollutant wastes from floating net cages (KJA) feed residue, local community waste, and agricultural activities around Lake Buyan. Good water quality will have a positive impact on the fish, ensuring the continuity of tilapia production supply in the desired amount, while poor water quality can cause fish growth and welfare to suffer.

Cultivation locations are a determinant component for successful tilapia farming at Warkuk Ranau Selatan District. It affects the sustainability of aquaculture activities and ecosystems in its area. The location of the cultivation is closely related to the water quality parameters supporting the cultivation process (Muhaemi et al 2015). The waste materials generated by various human activities need to be considered because they affect the quality of the water physically, chemically, and biologically (Purwanto et al 2014; Novita et al 2015; Harianto & Efendi 2017). This study aimed to provide information about the quality of the waters of Lake Ranau in Warkuk Ranau Selatan District, Indonesia.

Material and Method

Study area. This research was conducted in January 2020 in Lake Ranau Waters, Warkuk Ranau Selatan District, South OKU Regency, South Sumatra Province, Indonesia (Figure 1). The sampling location was selected based on the difference of KJT surface: the waters of Gedung Ranau (station I) was the control location, with no KJT activity, Tanjung Jati (station II), with a KJT surface of 2900 m^2, Way Wangi Seminung (station III), with a KJT surface of 22005 m^2, whereas the Kota Batu (station IV), with a KJT surface of 37895 m^2.

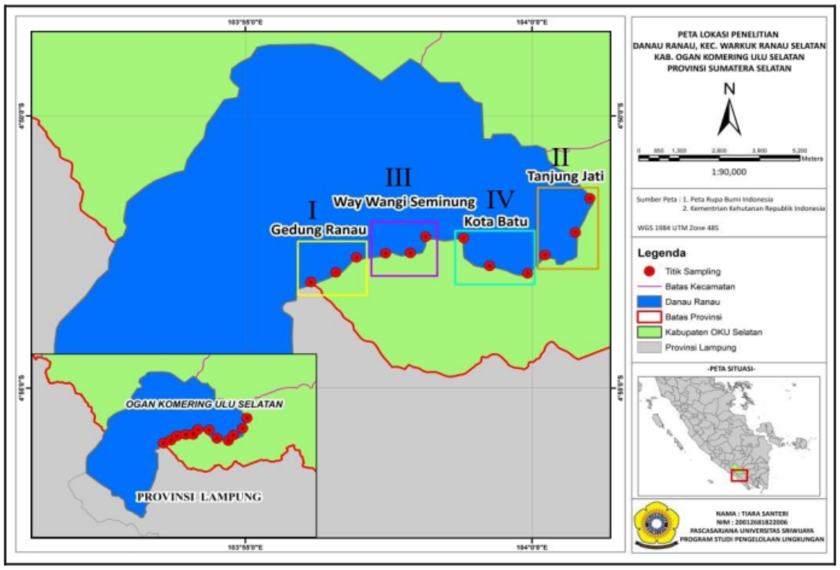

Figure 1. Research location.

Data collection. The data collected in this study consisted of primary and secondary data. Primary data collected included data on water quality measurements and market observations to determine the diversity of fish species in the Warkuk Ranau Selatan District market and its surroundings, while secondary data was obtained from relevant agencies, including general conditions of research stations, area maps, government regulations, and literature studies or other references in the form of journals, books, articles from prior research and other relevant data. Primary data collection was carried out *in-situ* (direct observation) and *ex-situ*, with analyses in the chemical laboratory of the Environmental Health Engineering Institute for Disease Control (BTKL-PP) and the biological laboratory of the Public Aquatic Fisheries Research and Fisheries Research Institute (BRPPUPP). *In-situ* data analysis included the determination of temperature, salinity, depth, brightness, turbidity, current speed, dissolved oxygen (DO), and pH (Table 1). The *ex-situ* data analysis included determination of nitrate, nitrite, ammonia, phosphate, sulfide concentrations, and abundance of phytoplankton (Hasan et al 2016). The water samples were put into 2 L sample containers for the measurement of chemical parameters. The water samples for phytoplankton analysis were placed into 250 mL sample containers and dripped with 1% lugol. At each station, water quality measurements were carried out 3 times, in 3 different places in the stations.

Table 1

Lake water quality analysis method

Parameters	*Analysis Method*	*Explanation*
Temperature (°C)	SNI 06.6989.23-2005	Thermometer
Brightness (m)	Wetzel & Likens (1991)	Secchi Disk
Turbidity (ntu)	SNI 06-6989.25-2005	Turbidimeter
Depth (m)	Wetzel & Likens (1991)	Strappy Anchor
Current speed (m s^{-1})	SNI 03 2414-1991	Current Meter
DO (mg L^{-1})	SNI 06.6989.14-2004	DO Meter
pH	SNI 06.6989.11-2004	pH Meter
Ammonia (mg L^{-1})	SNI 06-6989.30-2005	Laboratory
Nitrate (mg L^{-1})	SNI 06-2480.1991	Laboratory
Nitrite (mg L^{-1})	SNI 06-6989.9-2004	Laboratory
Phosphate (mg L^{-1})	SNI 06-6989.31-2005	Laboratory
Sulfide (mg L^{-1})	SNI 19-6964.4-2003	Laboratory
The abundance of phytoplankton (ind L^{-1})	APHA 10200 B - 2012	Plankton net

Note: DO - dissolved oxygen.

The abundance of phytoplankton was calculated based on equations according to APHA (2012), as follows:

$$N = (Oi/Op) \times (Vr/Vo) \times (1/Vr) \times n/p$$

Where: N - phytoplankton abundance; Oi - cover-glass area; Op - view area; Vr - filtered water volume; Vo - observed water volume; n - number of phytoplankton in the entire view area; p - number of view areas.

Analysis of water quality based on the Pollution Index method. The data analysis of Lake Ranau water quality used the Pollution Index (PI) method. This index is used to determine the level of relative pollution to acceptable water quality parameters. Based on the Decree of the Minister of Environment No 115 of 2003 Annex II, the first step to calculate the PI value is comparing the concentration of each polluted parameter (Ci) with the quality standard (Li). Thus, the measurement results (Ci/Li) are obtained for each parameter. The PI value was calculated with the following equation:

$$PIj = \sqrt{\frac{\left(\frac{Ci}{Lij}\right)_M^2 + \left(\frac{Ci}{Lij}\right)_R^2}{2}}$$

Where: PIj - pollution index for the designation of j; Ci - concentration of water quality parameters i; Lij - concentration of water quality parameters i listed in the water designation standard j; M - maximum; R - average.

The water quality assessment categories based on the pollution index value (PIj) are as follows:

Table 2

Water quality classification from the US Environmental Protection Agency

Number	*The Pollution Index Value*	*Category*
1	$0 \leq PIj \leq 1$	Meet the quality standard
2	$1 < PIj \leq 5$	Lightly polluted
3	$5 < PIj \leq 10$	Moderately polluted
4	$PIj > 10$	Heavily polluted

Note: source: Environmental Protection Agency (1975).

Analysis of water quality for the development of Nile tilapia cultivation sites. This analysis is needed to prepare, control, estimate the impact, and further manage the farming activities, to not pollute the environment. Water quality parameter criteria that support the development of tilapia aquaculture using KJT can be seen in Table 3.

Table 3

Criteria for water quality parameters at tilapia cultivation locations using embedded net cages

Parameters	*Weight*	*Parameter Score*					
		Very Good	*Score*	*Medium*	*Score*	*Bad*	*Score*
[2]Temperature (°C)	3	28-32	5	25–<28	3	<25	1
[4]Brightness (m)	2	≥5	5	3–<5	3	<3	1
[4]Turbidity (ntu)	2	≤5	5	5–30	3	>30	1
[6]Depth (m)	1	>3	5	3–2	3	<2	1
[5]Current speed ($m\ s^{-1}$)	2	0-0.3	5	0.4–1	3	>1	1
[2]Dissolved oxygen ($mg\ L^{-1}$)	3	>5	5	3–5	3	< 3	1
[6]pH	1	7–8	5	6.5–<7	3	<6.5–>9	1
[7]Ammonia ($mg\ L^{-1}$)	1	<0.02	5	0.02–0.05	3	>0.05	1
[3]Nitrate ($mg\ L^{-1}$)	1	<2	5	2–5	3	>5	1
[6]Nitrite ($mg\ L^{-1}$)	1	<0.04	5	0.04–0.06	3	>0.06	1
[3]Phosphate ($mg\ L^{-1}$)	1	<1	5	1–2	3	>2	1
[6]Sulfide ($mg\ L^{-1}$)	1	<0.002	5	0.002-0.005	3	>0.005	1
[1]The abundance of phytoplankton ($ind\ L^{-1}$)	1	≥15000	5	2000-15000	3	≤2000	1

Note: Astuti et al (2016)[1]; Carman & Sucipto (2013)[2]; Haris & Yusanti (2019)[3]; Hartami (2008)[4]; Khairunnisa et al (2015)[5]; Muhaemi et al (2015)[6]; SNI 6139:2009[7].

Muhaemi et al (2015) explained that the water quality characteristics can be calculated from the total score from the multiplication of the parameter value (A) with its weight (B), which is then used to determine the feasibility class of the Nile tilapia cultivation location:

Total Scoring = (Total Score/Total Score Max) x 100

Based on these calculations, the score of the water feasibility was obtained as presented in Table 4.

Table 4

Water feasibility score

Number	*Range of values (%)*	*Status*
1	80–100	Very good
2	50–<80	Medium
3	<50	Bad

Note: source: Muhaemi et al (2015).

Statistic analysis. Data analysis was carried out by using the analysis of variance (ANOVA) to determine significant relationships or differences in water quality parameters influenced by the difference in the surface of KJT. Subsequent data processing was carried out by tabulating the data, and presented in the form of a trend graph based on the cage surface. Trend analysis was used to determine the changes in water quality parameters as a reflection of the effect of changes in the increase of the number of KJT in the waters of Lake Ranau.

Results and Discussion

Evaluation of water quality based on the Pollution Index method. The value of the measurement results of the average water quality parameters during the observation are as follows in Table 5.

Table 5

The average value of the measurement results for water quality parameters

Parameters	*Unit*	*Research Location* *Gedung Ranau (Station 1)*	*Tanjung Jati (Station 2)*	*Way Wangi Seminung (Station 3)*	*Kota Batu (Station 4)*
Temperature	°C	27.7	27.8	27.9	27.9
Brightness	m	4.48	3.32	3.17	3.07
Turbidity	ntu	0,84	0.92	0.95	1.41
Depth	m	8.17	4.72	3.97	3.81
Current speed	$m\ s^{-1}$	0.08	0.084	0.087	0.085
Dissolved oxygen	$mg\ L^{-1}$	3.1	3	2.9	2.9
pH		7.62	8.05	7.9	8.04
Ammonia	$mg\ L^{-1}$	0.001	0.02	0.003	0.02
Nitrate	$mg\ L^{-1}$	3.7	2.4	2.6	3.8
Nitrite	$mg\ L^{-1}$	0.004	0.001	0.001	0.014
Phosphate	$mg\ L^{-1}$	0.161	0.129	0.15	0.14
Sulfide	$mg\ L^{-1}$	0	0	0	0
The abundance of phytoplankton	$ind\ L^{-1}$	19817	20750	29883	15067

The results of data analysis from observations in the 4 stations in the waters of Lake Ranau have the scores presented in Table 6.

Table 6

Score of Lake Ranau water quality parameters based on the Pollution Index method

Surface of embedded net cages	*Stations*	*Total score*	*Quality status*
0 m^2	I	0,66	Meet the quality standard
2900 m^2	II	0,75	Meet the quality standard
22005 m^2	III	0,71	Meet the quality standard
37895 m^2	IV	0,76	Meet the quality standard

Based on the results of calculations using the Pollution Index method, it can be seen that the water quality conditions in Station I, Station II, Station III and Station IV still meet the quality standard. Meanwhile, Kota Batu has a higher pollution index value than other stations. Pollution that occurs in Kota Batu is caused by ammonia concentrations that exceed the quality standard (0.03 $mg\ L^{-1}$).

The high KJT surface in Kota Batu is thought to cause ammonia pollution. Overfeeding and high excretion increase the ammonia concentration in Kota Batu waters. The remains of feed that settle to the bottom undergo a process of decay resulting in ammonia (Yulhadis et al 2018). Overall, the results of the analysis using the STORET method show that each station supports fixed KTJ activities, because the scores at the 4 stations are classified as good.

The effect of KJT on water quality. The temperature parameters at the study site ranged from 27.7 to 27.9°C. Figure 2 shows that the relationship between temperature and cage surface is strong (89%). Temperature is known to have a positive influence on KJT, a high temperature positively affecting the number of KJT in these waters. The temperature parameters in each fixed net cage were not different ($p>0.05$).

Based on Government Regulation No. 82 of 2001 (class II), the temperature range in these waters supports the survival of aquatic organisms, with a deviation of 3°C from the optimal value. Adawiyah et al (2018) stated that the temperature of water bodies is influenced by season, latitude, time of day, air circulation, cloud cover, flow and depth of water bodies. Optimal water temperature supporting the growth of Nile tilapia is 28°C (Tatangindatu et al 2013). According to Aliyas et al (2016), the water temperature will affect the appetite and metabolic processes of fish. The digestion in fish is slow when the temperature is low, whereas in warm temperatures the digestion is faster.

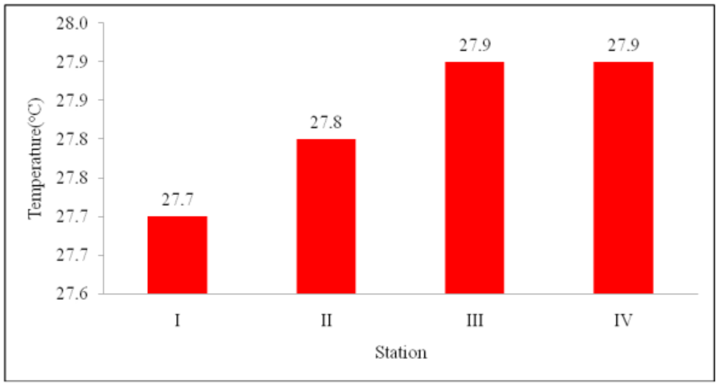

Figure 2. The temperatures in the 4 stations.

In general, the brightness in the waters of Lake Ranau is considered good for the growth of tilapia. According to Hasim et al (2015), the optimal value of water transparency for aquaculture in waters ranges from 20 to 40 cm. The water transparency in the 4 locations ranged from 3.07 m to 4.48 m.

From Figure 3, it can be seen that the brightness had a strong relationship with the cage surface (74.5%). Figure 3 indicates that the brightness is decreasing as the KJT activity increases in these waters. The contribution of waste from fish found in KJT can cause the turbidity to increase. The decrease in brightness level due to cage activity can be caused by suspended feed residue (Maniagasi et al 2013). The large number of anthropogenic activities carried by the current also causes low brightness.

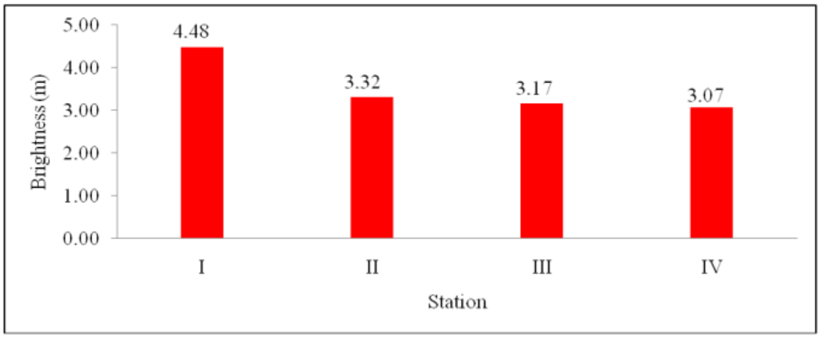

Figure 3. Brightness in the study stations.

Figure 4 shows that the level of water turbidity tended to be higher with increasing KJT activity, with a determination coefficient value of 76%. Thus, the relationship of turbidity to cage surface is strong. ANOVA test outputs show that the significance value is 0.004 ($p<0.05$), a significant difference occurring in turbidity at the 4 observation stations. The level of water turbidity at each observation station ranges from 0.84 ntu to 1.41 ntu, in good limits for Nile tilapia.

The ideal turbidity value for fish farming should not exceed 5 ntu (Hartami 2008). The highest level of turbidity is at station 2 (Kota Batu), because of the highest surface of KJT. Cages provide a pollution load in the water, causing water turbidity (Saputra et al 2017). In addition, household waste dumped directly into water bodies result in high levels of turbidity in the waters.

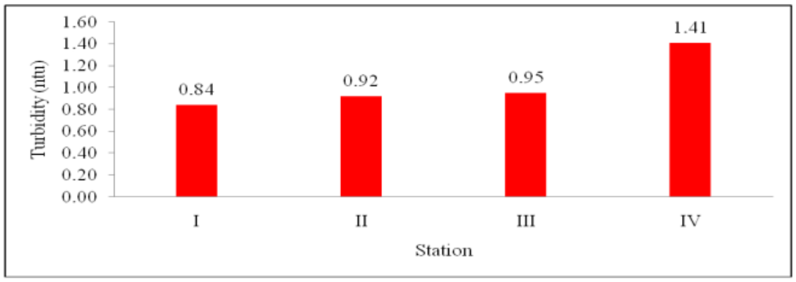

Figure 4. Turbidity in the 4 study stations.

Depth is one of the physical parameters that affect the brightness of the waters, the brightness being lower in deeper waters (Adawiyah et al 2018). The results of the depth measurement obtained in the waters of Lake Ranau are suitable for the life of Nile tilapia, the values ranging from 3.81 m to 8.17 m. Muhaemi et al (2015) stated that the ideal water depth for freshwater cage cultivation is at least 2 m. Space for the fish to move will increase with increasing water depth. The analysis of variance (ANOVA) shows that there was a significant difference ($p<0.05$) in depth at the 4 KJT locations, denser KJT being present in lower depths. Station IV is significantly different from station I, station II, and station III.

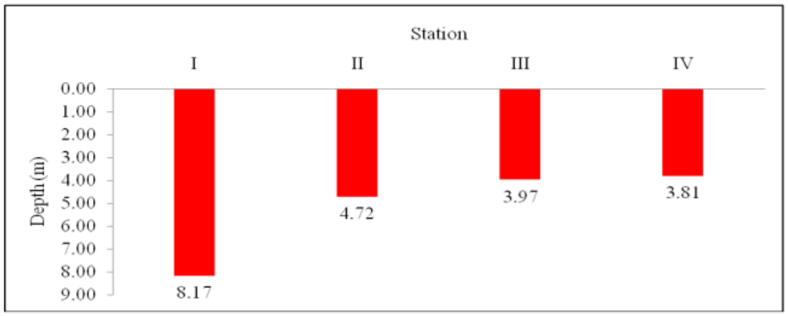

Figure 5. The depth in the 4 study locations.

The surface current speed values in the 4 stations do not have significant differences. The average current speeds range from 0.08 to 0.087 m s^{-1} in the 4 stations, as presented in Figure 6. The current speed is slow and feasible for KJT activities. In general, lakes have calm water, the water moving at a very slow speed. Khairunnisa et al (2015) explained that the lake is classified into tapered waters, where generally the movement of water in the lake is limited due to the strength of the wind.

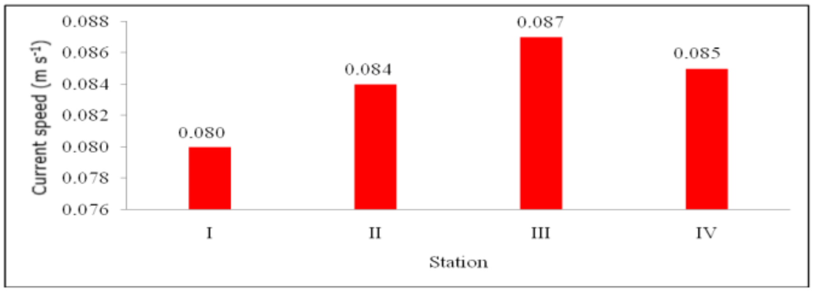

Figure 6. Current speed in the 4 stations.

DO is needed by all aquatic organisms for respiration, metabolic processes, or exchange of substances, helping the production of energy for growth and culture (Hamuna et al 2018). DO concentrations at the study sites ranged from 2.9 to 3.1 mg L^{-1}. The relationship between DO and cage surface is strong, the DO being higher with a lower KJT activity (Figure 7). However, the difference in DO at the observation stations was not significant ($p>0.05$).

The DO concentration obtained indicates that the waters of Lake Ranau meet quality standards. The lowest DO concentration was found in Station III and Station IV, 2.9 mg L^{-1}. The results of Utomo et al (2017) also show that the DO content in Lake Ranau has a low number, with values ranging from 1.61 to 5.23 mg L^{-1}. The large number of fish farming activities using net cages in Stations IV and III and residential activities contribute to the low DO. Elfidasari et al (2015) stated that the decrease in DO levels is caused by a large amount of organic waste originating from activities in lake water bodies, especially fish farming activities and waste. According to the Government Regulation 82 from 2001, the concentration of DO for fish farming should be at least 3 mg L^{-1}. The low DO in Stations III and IV is thought to have also been caused by the high temperature in these waters, DO levels decreasing in high temperatures (Adawiyah et al 2018).

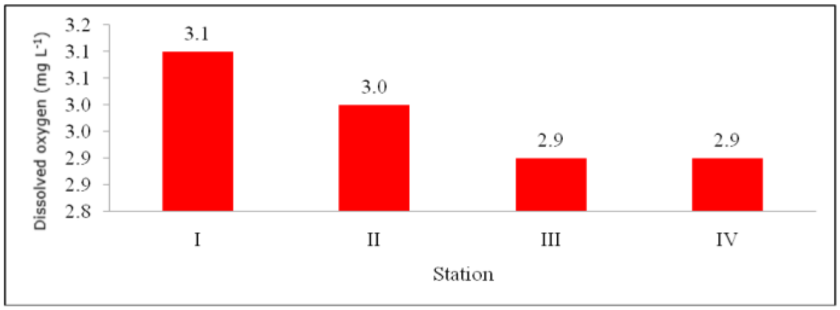

Figure 7. Dissolved oxygen in the 4 study stations.

The measurement results of the average pH values ranged from 7.62 to 8.05 in the 4 stations. Based on quality standards, the pH values in the waters of Lake Ranau do not exceed the quality standard set by Government Regulation 82 of 2001, namely 6 to 9. The pH value of lake water is good for Nile tilapia aquaculture. According to Muhaemi et al (2015), a good pH value for tilapia farming activities ranges from 6 to 9. The pH has a strong relationship with cage surface, where the water has a higher pH in areas with higher KJT activities (Figure 8). The entry of organic and inorganic waste into the waters can affect the pH value that comes from domestic activities and fish cultivation (Selanno et al 2016).

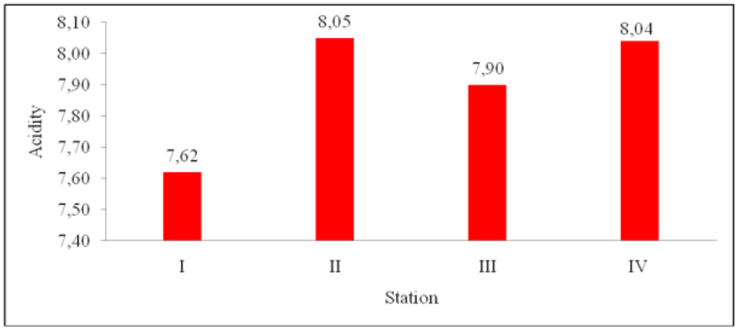

Figure 8. Water pH in the 4 stations.

The ammonia in Lake Ranau water ranged from 0.001 to 0.02 mg L^{-1}. Ammonia has a very strong relationship with cage surface, where the coefficient of determination is 1 (Figure 9). The more KJT activity means a greater excretion by the fish, which causes high ammonia content. The highest ammonia content was in Stations IV and II. Kota Batu (station 4) is the village with the most tilapia farming businesses using KJT, while in Tanjung Jati there are only a few KJT activities, but there are also KJA in the proximity, currents carrying some fish waste from them to the station. The ammonia value at each observation location is normal because it does not exceed the standard ammonia concentration permitted by Government Regulation No. 82 of 2001 for cultivation activities. The quality standard for ammonia was less than 0.02 mg L^{-1}. The content of free ammonia toxic to tilapia and that can cause fish death is between 0.1-0.2 mg L^{-1} (Carman & Sucipto 2013).

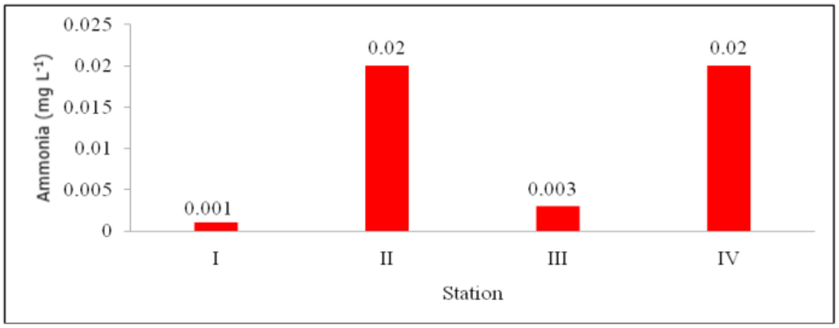

Figure 9. Ammonia content in the 4 stations.

The content of nitrate (NO$_3$) in the waters of Lake Ranau was relatively low, with averages between 2.4-3.8 mg L^{-1}. Government Regulation Number 82 from 2001 requires a nitrate content of less than 20 mg L^{-1} for fishery activities. This shows that the nitrate content in these waters is not harmful to the life of tilapia. Based on Figure 10, the nitrate content appears to have a very strong relationship with cage surface, 99.2%.

The highest nitrate concentration occurs in the area with the highest KJT surface, namely Kota Batu (station 4). This can be influenced by the excess of feed waste, domestic waste, and fish waste, which is broken down by bacteria into inorganic material in the form of nitrate. Irhayyim & Fotedar (2019) explained that uneaten feed is a source of nitrogen waste. Gedung Ranau, which did not have KJT activity, also had a high nitrate concentration after Kota Batu, presumably due to a large amount of domestic waste from the people living around the waters. This is in line with the research of Haris & Yusanti (2019), who describe the high nitrate due to pollution from human activities and animal feces.

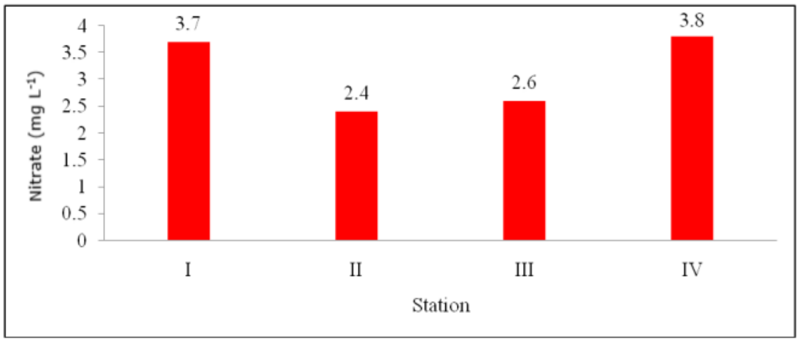

Figure 10. Nitrate concentrations in the 4 stations.

The content of nitrite at each station meets the quality standard requirements for water contamination of the Government Regulation Number 82 from 2001 regarding Class III water requirements, where the value range is from 0.001 to 0.014 mg L^{-1}. Figure 11 shows that the nitrite content of stations II and III is significantly different from the nitrite content at stations I and IV ($p<0.05$). With more KJT activity, the nitrite concentration is higher. The highest nitrite content is in the waters of Stations IV and I. The high level of nitrite in station IV is closely related to the waste material from the metabolism of fish cultivated using KJT. The results of Tokah et al (2017) also show that high organic matter from fish farming increases the concentration of nitrite in the water.

Station IV is influenced by the large number of people who use these waters. The high population in the area is partially the cause of a large amount of domestic anorganic and organic waste discharged to water bodies. The high content of organic matter in the waters can cause eutrophication, reducing DO levels (Simbolon 2016).

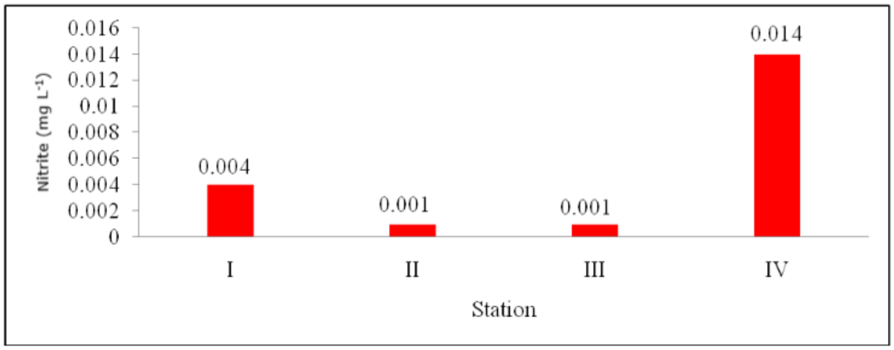

Figure 11. Nitrite concentrations in the 4 stations.

Sulfide (H_2S) can cause problems because it dissolves easily, it is toxic, and causes an unpleasant odor (Lihawa & Mahmud 2017). High sulfide concentrations will reduce DO levels in waters, resulting in fish mortality (Apendi et al 2019). The results of the analysis for the sulfide content in the waters of Lake Ranau show that the sulfide content was 0, meaning that it was following the quality standards as stated in Government Regulation Number 82 from 2001, which is less than 0.02 mg L^{-1}. This is thought to be due to the low decomposition of organic materials containing sulfur by anaerobic bacteria.

Phosphates at cultivation locations in the waters of Lake Ranau were in concentrations ranging from 0.129 to 0.161 mg L^{-1}. The phosphate content at the study sites did not vary significantly and had a very strong relationship with KJT (Figure 12). The phosphate values meet the quality standard value. According to Government Regulation Number 82 from 2001, the quality standard value for phosphate (PO_4) is less than 1 mg L^{-1}.

Haris & Yusanti (2019) stated that a phosphate content less than 1 mg L^{-1} is good for developing cultivation activities. The highest phosphate content was found in the waters of the Gedung Ranau, which is the control location, without KJT activity. This is thought to have originated from the large number of settlements that produce organic waste. These waters as used for baths, wash, and toilet necessities by people who are living near the lake.

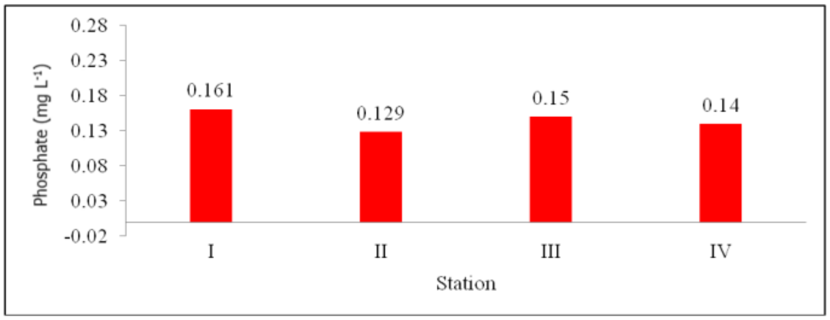

Figure 12. Phosphate concentrations in the 4 stations.

The phytoplankton found in the waters of Lake Ranau, Warkuk Ranau Selatan District consists of 30 genera from 3 classes: Bacillariophyceae, Chlorophyceae, and Cyanophyceae. Chlorophyceae class is the most common phytoplankton. Figure 13 shows that Way Wangi Seminung has the highest abundance of phytoplankton, which is thought to be due to the movement of water masses that carry nutrients in that location. Nutrient content, currents, wind, light, and predators are all factors that influence the presence of phytoplankton in a water body (Garno 2008; Juadi & Nurfadillah 2018). The abundance of phytoplankton in the waters of Lake Ranau is between 15067-29883 ind L^{-1}. Thus, these waters are eutrophic, but still support the life of aquatic organisms, especially fish. Eutrophic waters are waters with high fertility rates, where the abundance of phytoplankton is higher than 15000 ind L^{-1} (EPA 1975).

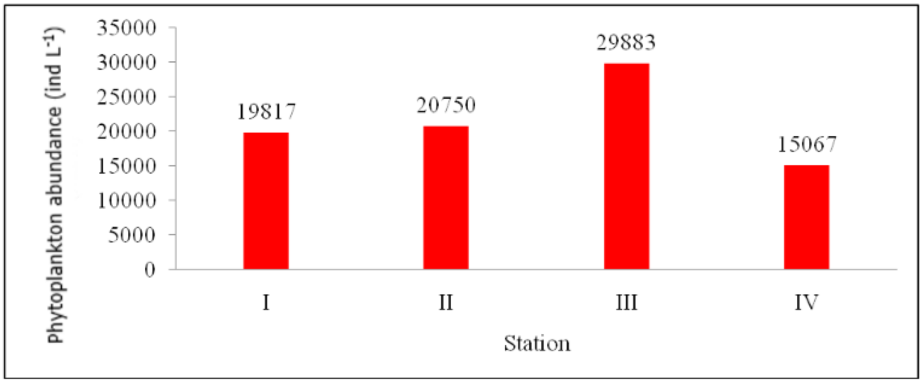

Figure 13. The abundance of phytoplankton in the 4 study stations.

Water quality status for the development of Nile tilapia farming locations. Based on the weighted results of the criteria for water quality parameters, the waters of Lake Ranau are good for Nile tilapia aquaculture activities.

Table 7

Status of water quality for the development of Nile tilapia cultivation locations in Ranau Lake watershed cages in Warkuk Ranau Selatan District, Indonesia

Station	*Area*	*Total of Values*	*Status*
I	Gedung Ranau	88	Very Good
II	Tanjung Jati	86	Very Good
III	Way Wangi Seminung	88	Very Good
IV	Kota Batu	86	Very Good

From the weighting and scoring results in the waters of Lake Ranau, the suitability score for Nile tilapia cultivation in Station IV is 86%, in Station II it is 86%, in Station III it is 88%, and in Station I it is 86%. Based on the results of the feasibility analysis, these waters are classified into the very good category to support the survival of Nile tilapia.

There are several parameters in these waters that need some attention to optimize Nile tilapia aquaculture. DO in Kota Batu (station 4) and Way Wangi Seminung (station III) is lower than in Tanjung Jati and Gedung Ranau for Nile tilapia aquaculture. A large number of KJT near the shore could have caused the low DO in both locations. The KJT trigger an increase in the organic waste, the decomposition process requiring oxygen, decreasing its levels (Simbolon 2016). Meanwhile, the brightness, ammonia, and nitrate parameters did not reach the optimal score, but they were still categorized as good for Nile tilapia aquaculture. A polluted aquatic environment makes Nile tilapia susceptible to disease (Abadi et al 2020). To maintain the tilapia habitat, more attention is needed to the water quality parameters that do not reach the optimal score, so that Nile tilapia cultivation in KJT can be carried out properly.

Conclusions. The quality of the waters of Lake Ranau, Warkuk Ranau Selatan district is in a good category and supports fish farming activities. Water quality parameters generally meet class III water quality standards by the Government Regulation No. 82 of 2001, except for the ammonia at Station IV (Kota Batu) with the highest KJT surface, where the value exceeds the quality standard. The effect of water cage surface on some water quality parameters is strong. The relationships between temperature, DO, current speed, salinity, and sulfide parameters with cage surface are classified as weak or not significant.

The development of KJT in the waters of Lake Ranau, Warkuk Ranau Selatan District, Indonesia, is strategic for Nile tilapia fish farming activities. However, the number of KJT activities must still be limited and the zoning must be appropriate. The government, stakeholders, and the community need to protect these waters, to minimize anthropogenic waste, to reduce the pollution load originating from KJT in Lake Ranau.

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