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SEASONAL INFLUENCE ON WATER QUALITY STATUS OF TEMENGGOR LAKE, PERAK

(Pengaruh Musim Terhadap Kualiti Air Tasik Temenggor, Perak)

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Abstract

A study of the water quality in Temenggor Lake was conducted within two different seasons, namely wet season (November – January 2009) and dry season (March – July 2010). Thirteen sampling stations were selected representing open water body of the lake particularly surrounding Banding Island. Three depths layered sampling (surface, middle and bottom of lake) was performed at each sampling stations except in zone B. An average WQI for Temenggor Lake in wet season (90.49) is slightly higher than the average for dry season (88.87). This study indicates quite significant seasonal influence of rainfalls on environmental lake ecosystems by improving the quality through dilution effect on several parameters. Statistical analysis of two-way ANOVA test indicates that all measured parameters are affected by seasonal changes except for pH, turbidity, DO, BOD, oil and grease. Biochemical Oxygen Demand (BOD) and water hardness showed significant relationship with local community activities. Considering future development as ecotourism destination, the water quality of Temenggor Lake should be maintained thus some sort of integrated lake management system model on the integrated water resource management concept should be implemented.

Keywords: Temenggor Lake, Water Quality, Seasonal Variation

Abstrak

Satu kajian kualiti air di Tasik Temengor telah dijalankan dalam tempoh dua musim yang berbeza iaitu, musim basah (November – Januari 2009) dan musim kering (Mac – Julai 2010). Tiga belas stesen persampelan telah dipilih mewakili sistem air terbuka tasik terutamanya sekitar Pulau Banding. Persampelan pada tiga kedalaman (permukaan, tengah dan dasar tasik) telah dijalankan di semua stesen persampelan kecuali zon B. Nilai purata IKA untuk Tasik Temengor pada musim basah (90.49) adalah lebih tinggi berbanding daripada musim kering (88.87). Kajian semasa menunjukkan pengaruh yang cukup besar oleh hujan semasa musim basah ke atas ekosistem tasik dengan cara meningkatkan kualiti melalui kesan pencairan terhadap beberapa parameter. Analisis statistik ANOVA dua hala menunjukkan bahawa kesemua parameter yang diukur terjejas oleh perubahan bermusim kecuali pH, kekeruhan, oksigen terlarut, BOD serta minyak dan gris. Permintaan oksigen biokimia dan keliatan air menunjukkan hubungan yang signifikan dengan aktiviti masyarakat setempat. Memandangkan pembangunan sekitar tasik dimasa hadapan sebagai destinasi eko pelancongan, kualiti air Tasik Temenggor perlu dikekalkan. Oleh itu suatu model sistem pengurusan bersepadu tasik bersandarkan konsep pengurusan sumber air bersepadu (IWRM) perlu dilaksanakan.

Kata kunci: Tasik Temenggor, Kualiti Air, Perubahan Musim

Introduction

Temenggor Lake is the largest man-made lake in Perak, and the second largest in Peninsular Malaysia. This catchment area of 152 km^2 formed as a result of hydroelectric dam established in 1974 and completed in 1977. The dam water is also used as a drinking water supply for northern peninsular of Malaysia populations [1]. Temenggor Lake is divided into three zones namely Conservation Zone, Recreational Fishing Zone and Commercial Zone. Conservation Zone includes upstream of Temenggor Lake such as Kejar River, Tiang River and Gadong River.

Increased in human population has resulted in new human settlements around lakes which served as water resources or tourism area which resulted in the deterioration of water quality [2,3]. Having mega diversity of flora and fauna as partly within the Royal Belum Temenggor Conservation area, Temenggor Lake was noted as a popular freshwater ecosystem as well developed in line with the concept of ecotourism. However no proper study on the water quality of the lake was performed. It is imperative that a study be carried out to evaluate the status of lake's water quality. This study was carried out for the purpose as well as to identify any possible pollution sources and to assess the impact of Orang Asli settlement on the lake's water quality.

Materials and Methods

Sampling Activity

Field sampling was conducted within wet season (November – January 2009) and dry season (March – July 2010). A total of 13 sampling stations were divided into 2 main zones namely zone A: Banding Island which is considered as part of commercial area and zone B: Royal Belum Temenggor which is noted as conservation area. Portable GPS was used to determine the coordinate each sampling station on location as presented in Table 1. Water samples were collected at three depths from each sampling station except for zone B in which depth measurement less than 5 m. Van Dorn water sampler was used to collected sample before transfer into 1000 mL HDPE and glass bottle prior for laboratory analysis.

Table 1. Sampling Station, Coordinate and Depth Measurement for Temenggor Lake Study

Station	Location	Coordinate		Depth (meter)	
		Latitude	Longitude	Wet	Dry
	Zone A: Banding Island				
SS01	Banding Fisheries Centre	05° 33.138 N	101° 21.180 E	10.32	8.12
SS02	Banding Island Public Jetty	05° 33.097 N	101° 20.887 E	7.80	5.66
SS03	Mohd Shah Resort	05° 32.928 N	101° 21.190 E	21.20	20.07
SS04	Banding Island Southern Region	05° 31.748 N	101° 20.845 E	13.00	11.45
SS05	Banding Island Resort	05° 33.522 N	101° 20.481 E	11.05	10.03
SS06	Banding Island Resort (discharge point)	05° 32.559 N	101° 20.404 E	4.30	4.20
SS07	Banding Island Northern Region	05° 33.951 N	101° 20.103 E	11.00	8.77
	Zone B: Royal Belum Temenggor				
SS08	Orang Asli Settlement Tiang River	05° 33.950 N	101° 20.105 E	4.30	2.10
SS09	Orang Asli Settlement Tiang River Middle Pathway	05° 41.659 N	101° 26.515 E	3.50	2.55
SS10	Orang Asli Settlement Kejar River	05° 47.447 N	101° 24.502 E	3.50	3.01
SS11	Base Camp Kejar River	05° 47.437 N	101° 24.504 E	2.70	2.50
SS12	Perak River Upstream	05° 48.592 N	101° 25.286 E	2.90	1.49
SS13	Mess Estuary (Kejar River)	05° 48.056 N	101° 24.896 E	5.20	3.84

Samples were stored in a cool box containing ice cube at temperature of approximately 4 ºC before transferring to Pulau Banding Rainforest Research Center (PBRRC) for further analysis. All sampling, preservative and samples handling technique were in accordance with APHA 1998 for Examination of Water and Wastewater (20th Edition) [4].

***In situ* Measurement**

Physical water quality was measured *in situ* using YSI model 550 multi sensor probe for pH, temperature, turbidity, conductivity and dissolved oxygen. Depth level of each sampling station was measured using an echo sounder® model speedtech. Calibration of every YSI model 550 probes was conducted in the laboratory prior before field sampling and once again after sampling progress work was done.

Laboratory Analysis

All samples collected from the field were kept in a refrigerator at a temperature below 4°C to reduce all the activities and metabolism of the organisms in the water. Preliminary analysis for various chemical parameters such as suspended solid, oil and grease were performed at the Pulau Banding Rainforest Research Centre. Further analysis (COD, nitrate, phosphate, and metals) were performed at chemistry laboratory, UKM.

List of method used were Ammoniacal-Nitrogen (*Salicylate Method*), Water Hardness (*EDTA Titration Determination*), Suspended Solids (*Gravimetric Method*), Biochemical Oxygen Demand (*Incubation Method* as BOD_5), Chemical Oxygen Demand (*Reactor Digestion and Colorimetric Determination*), Oil & Grease (*Extraction-Gravimetric Method*), Nitrate (*Cadmium Reduction Method*) and Phosphate (*Ascorbic Acid Method*). Ammonia-N, Chemical Oxygen Demand, Nitrate and Phosphate were determined by using a spectrophotometer Model HACH DR 2000 at a specified wavelength (APHA 1998; HACH 2003).

Results and Discussion

The range, mean and standard deviation of *in situ* measurement parameters within seasonal change are as shown in Table 2. Statistical analysis shows that only temperature and turbidity as *in situ* parameters measured in this study have significant differences ($P<0.05$) between seasonal change. In term of spatial variation only dissolved oxygen have significant differences ($P<0.05$). Correlation analysis was also conducted to examine the relationship between different variables.

Table 2. Range, mean and standard deviation for *in situ* parameters

Parameter	Wet Season		Dry Season	
	Range	**Mean (SD)**	**Range**	**Mean (SD)**
Temperature (ºC)	23.35 – 29.34	27.53 ± (1.85)	26.52 – 30.23	28.68 ± (1.24)
pH	6.72 – 8.32	7.29 ± (0.49)	6.89 – 7.71	7.35 ± (0.25)
Conductivity (μScm^{-1})	30 – 50	37.74 ± (5.06)	37 – 52	42.63 ± (4.16)
Turbidity (NTU)	2 – 7	2.85 ± (1.41)	3 – 26	6.31 ± (6.33)
Dissolved Oxygen (mgL^{-1})	4.15 – 9.03	6.79 ± (1.85)	3.32 – 8.73	6.67 ± (1.47)

Rainfall

The rainfall data through the sampling period was provided by Malaysia Meteorological Centre. From November 2009 to July 2010, 49.60 – 174.30 mm of rainfall was recorded in Temenggor Lake. Total number of raining days was 13 days as the start of raining season approximately in October till December every year. The monthly rainfall has shown significant relationship with parameters such as COD ($r = 0.673$), oil and grease ($r = 0.793$) and suspended solids ($r = 0.978$) .

Ammoniacal Nitrogen

The ammoniacal nitrogen concentrations was recorded to be in range of 0.02 – 0.05 (mean 0.03 ± 0.01) and 0.13 – 0.52 (mean 0.21 ± 0.09) mgL^{-1} respectively for wet and dry seasons. These findings showed that highest concentration for ammoniacal nitrogen was recorded at Mohd Shah Resort (SS03) with values of 0.05 mgL^{-1} (wet season) and at Base Camp Kejar River (SS11) with values of 0.52 mgL^{-1} (dry season).

Ammoniacal nitrogen is commonly produce from decomposition of urea and protein by products, thus it is normally abundance as domestic waste in hydrological ecosystem [5]. Hence previous study partially claimed that major contribution of ammonium pollution may come from septic systems, although decomposition of ammonium may occur in the drain field pathways [6]. Human activity is well known to play important role as contributor to ammoniacal nitrogen abundance in the lake ecosystems in which concentrations could be higher than 5 mgL^{-1}[7]. Low level of ammoniacal nitrogen concentrations recorded in this present study indicates that sources of pollution from septic systems namely at Mohd Shah Resort or the Base Camp at Kejar River were not yet significant for Temenggor Lake ecosystems.

Several previous studies related to agricultural field impact reported that an application of fertilizers used inorganic nitrate content could be a significant source for high concentrations of ammonium nitrate in lake ecosystems [7]. Otherwise less usage of phosphorus content in non-agricultural areas often associated with low levels of ammonium content [6]. Since there was no large scale agricultural activities around Temenggor Lake area, except for small plots around Orang Asli settlement, agricultural activities will not be the significant source of ammoniacal nitrogen in the Temenggor lake ecosystems.

Statistical analysis using two ways ANOVA test indicates that ammoniacal nitrogen has no significant differences between sampling stations ($P>0.05$) but significantly different on seasonal period ($P<0.05$) in which wet season recorded significantly higher than the dry season. Ammoniacal nitrogen has shown positive correlation with conductivity ($r = 0.664$) and turbidity ($r = 0.794$).

Water Hardness

The concentration of water hardness were recorded to be in the range of 2.00 – 13.20 (mean 5.35 ± 2.92) and 2 – 16 (mean 8.98± 4.01) mgL^{-1} respectively for wet and dry seasons. This study has shown that highest concentrations for hardness was recorded at Base Camp Kejar River (SS11) with values of 13.20 mgL^{-1} (wet season) and Orang Asli Settlement Tiang River (SS08) with values of 16 mgL^{-1} (dry season). This may be related to natural conditions at the stations and the impact of human activities particularly at Orang Asli settlement (SS08) and at Kejar River Base Camp (SS11). Moreover, the level of water hardness in dry season is probably enhanced by increasing evaporation rate in hydrological lake ecosystems [8].

The lowest concentration of water hardness was recorded at Banding Island Southern Region (SS04) with values of 2 mgL^{-1} for both seasons. This may be due to its location away from any human activities. Statistical analysis using two ways ANOVA test indicates that water hardness has no significant different between seasons but is significantly different between stations ($P<0.05$).

Total Suspended Solids (TSS)

The concentration of suspended solids were recorded to be in the range of 1.02 – 9.00 mgL^{-1} (mean 3.71 ± 1.87) and 2.33 – 17.80 mgL^{-1} (mean 7.03 ± 4.85) respectively for wet and dry seasons. This study has shown that highest concentrations for TSS was recorded at Orang Asli Settlement Tiang River (SS08) with values of 9 and 17.80 mgL^{-1} respectively for both wet and dry seasons. Overall low levels of suspended solids in Temenggor Lake indicates a remarkably good sign for lake's water quality.

The Orang Asli Settlement Tiang River (SS08) as expected recorded higher level of suspended solids compared to other stations, since it is at Orang Asli communities settlements which is major population in Royal Belum Temenggor, where activities of their daily works specifically of water usage for cleaning as well as disposal of domestic waste contribute to the increase in suspended solids. Furthermore, the use of boat as main transport around the settlement area where the depth of lake can be considered as low (which is less than 5 meter during dry season),

allow resuspension of sediments to occurs [9] thus promotes an increase in suspended solids concentrations in the lake ecosystems.

According to Ooshaksaraie et al. [10] rate of soil erosion will increase when the cover of vegetation was disturbed or removed. Consequently, it will cause a drastically increase in the amount of surface runoff and velocity entering the lake. In this present study, low level of suspended solids concentration recorded during wet season indicates that most of the lake's riparian areas are still highly vegetated.

The lowest suspended solids concentrations were recorded at Perak River upstream (SS12) with value of 1.02 mgL^{-1} (wet season) and at Banding Island Public Jetty (SS02) with value of 2.33 mgL^{-1} (dry season). Perak River upstream was highly expected to be very clean (very low in suspended solids) since factors such as far away from human disturbance and high water flow make it cleaner than other areas. The low levels of suspended solids recorded at Banding Island Public Jetty (SS02) during dry season may be due to the low tourist activities at the time of sampling. Statistical analysis using two ways ANOVA test indicates that suspended solids has no significant differences between sampling stations ($P>0.05$) but has shown significant differences on seasonal period with ($P<0.05$). Suspended solids has shown positive correlation with temperature ($r = 0.651$) at $P<0.05$.

Biochemical Oxygen Demand (BOD)

The concentration of biochemical oxygen demand (BOD) was recorded to be in range of 0.26 – 2.19 (mean 1.25 ± 0.57) and 0.24 – 3.26 (mean 1.42 ± 0.80) mgL^{-1} respectively for wet and dry seasons. This study has shown that highest value for BOD was recorded at Banding Fisheries Centre (SS01) with values of 2.19 mgL^{-1} (wet season) and at Orang Asli Settlement Tiang River (SS08) with values of 3.26 mgL^{-1} (dry season).

Since an availability of oxygen to living organism decreases with increasing BOD value, high BOD values obtained indicate maximum oxygen consumption and probably pollution load on the aquatic system [11] like what happen at station SS08. In this present study, the recorded BOD values were slightly higher in dry season but overall it can still be considered low and very much similar to those reported by Shuhaimi et al. [12] for Kenyir Lake (0.61 – 2.87 mgL^{-1}).

The lowest BOD concentrations were recorded at Base Camp Kejar River (SS11) with values of 0.26 mgL^{-1} (wet season) and also at Orang Asli Settlement Middle River Pathway (SS09) with values of 0.24 mgL^{-1} (dry season). The BOD value at station SS11 tend to be decline during wet rather than dry season possibly due to current changes that increase speed of water overflow after receiving input from station SS12.

Statistical analysis using two ways ANOVA test indicates that BOD has significant differences between sampling stations ($P<0.05$) but no significant differences on seasonal period ($P>0.05$). Low levels of biochemical oxygen demand recorded in this present study indicates that organic pollution is not yet significant for the lake ecosystems. Biochemical Oxygen Demand (BOD) has shown positive correlation with temperature ($r = 0.693$) COD ($r = 0.663$) and negative correlation with pH ($r = -0.584$) at $P<0.05$.

Chemical Oxygen Demand (COD)

The concentration of chemical oxygen demand (COD) was recorded to be in range of 9.00 - 34.67 (mean 17.47 ± 7.28) and 7.00 - 28.00 (mean 15.21 ± 5.95) mgL^{-1} respectively for wet and dry seasons. This study has shown that highest concentrations for COD was recorded at Banding Fisheries Centre (SS01) with values of 34.67 mgL^{-1} (wet season) and 28.00 mgL^{-1} (dry season). Activities at the centre may introduce some organic or chemical pollutions into the lake.

Higher concentrations of COD recorded in dry season may be due to less dilution of pollutant as noted for other parameters and by other study [11]. Statistical analysis using two ways ANOVA test indicates that COD has significant differences between sampling stations and seasonal periods ($P<0.05$). COD has also shown positive correlation with BOD ($r = 0.663$) also oil and grease ($r = 0.693$) at $P<0.05$. Despite some variations among stations, overall the level of COD, as of BOD, is still low indicating low level of organic and chemical pollution.

Oil and Grease

The concentration of oil and grease of Temenggor Lake was recorded to be in range of 0.667 -104 (mean 24 ± 23.27) and 11.73 - 62.20 (mean 31 ± 16.63) mgL^{-1} respectively for wet and dry seasons. This study has shown that highest concentrations for oil and grease was recorded at Banding Fisheries Centre (SS01) with values of 104 mgL^{-1} (wet season) and also at Orang Asli Settlement Tiang River (SS08) with values of 62.20 mgL^{-1} (dry season).

The highest value of oil and grease recorded at SS01 may be contributed local activities such as restaurant, boating, washing as well as water recreation from nearby Banding Island Public Jetty. In this present study, surprisingly the Banding Island Public Jetty (SS02) did not record high value of oil and grease as expected. This may be due to the low boating activities at the time of sampling. Higher values recorded at SS01 and SS08 may be due to local activities namely boating and related activities.

Statistical analysis using two ways ANOVA test indicates that oil and grease has significant differences between sampling stations and seasonal period ($P<0.05$). In this present study, at the moment boating activities have not significantly impact on the overall level of oil grease in the lake water. This may be due to the rapid mixing of water and low tourism activities at least during the sampling period. There were a positive correlation between oil grease and COD ($r = 0.693$) but having negative relationships with pH ($r = -0.585$) at $P<0.05$.

Nitrate

The concentration of nitrate was recorded to be in the range of 0.01 – 0.03 (mean 0.016 ± 0.01) and 0.03 – 0.05 (mean 0.042 ± 0.012) mgL^{-1} respectively for wet and dry seasons. This study has shown that the overall level of nitrate is very low. Highest concentrations of nitrate of 0.05 mgL^{-1} was recorded at SS05 (Island Resort near discharge point) in dry season.

The lowest concentration was obtained at Orang Asli Settlement Tiang River Middle Pathway (SS09) with values of 0.03 and 0.02 mgL^{-1} respectively for wet and dry seasons. Statistical analysis using two ways ANOVA test indicates that nitrate has not differ significantly between sampling stations and but differ significantly on seasonal period ($P<0.05$). The lower levels of nitrate recorded in this study indicates that sources of pollution from agriculture is not yet significant for the lake aquatic environment especially in term of spatial measurement. There were a positive correlation between nitrate content and phosphate ($r = 0.555$) at $P<0.05$.

Phosphate

The concentration of phosphate was recorded to be in range of 0.39 – 0.84 (mean 0.621± 0.14) and 0.13 – 0.63 (mean 0.33 ± 0.19) mgL^{-1} respectively for wet and dry season. The highest concentrations for phosphate was recorded at Mohd Shah Resort (SS03) with values of 0.84 mgL^{-1} (wet season) and at Banding Island Southern Region (SS04) with values of 0.63 mgL^{-1} (dry season).

As with nitrate, the low level of phosphate recorded overall in the lake water indicates that the lake did not yet expose to eutrophication. Similarly the lake seems not to receive high input of domestic waste water effluent since high concentrations of reactive phosphate is largely due to domestic waste water effluent enriched with phosphorus compounds [13].

Statistical analysis using two ways ANOVA test indicates that nitrate has no significant differences between sampling stations but differ significantly on seasonal period ($P<0.05$). There were a positive correlation at $P<0.05$ between phosphate and nitrate ($r = 0.555$), phosphate and conductivity ($r = 0.590$) and negative relationship with respect to DO value ($r = - 0.55$).

Water Quality Index (WQI)

Water quality index (WQI) commonly used to aggregate data on water quality parameters at different times and in different places and to translate this information into a single value that determines the duration and spatial units involved [14]. The values of WQI at all sampling stations for wet and dry seasons were determined by using an

expression adopted by Malaysia Department of Environment based on six parameters as give by the following expression [15]:

$$WQI = 0.22*S_IDO + 0.19*S_IBOD + 0.16*S_ICOD + 0.15*S_IAN + 0.16*S_ISS + 0.12*S_IpH$$

This study has shown that WQI ranges from 83.00 – 95.67 (wet season) and 76.67 – 94.01 (dry season), slightly better for wet season particularly for Mohd Shah Resort (SS03). Contrary to usual observation, the average water quality index in wet season with values of 90.49 was slightly higher than an average water quality index for dry season with values of 88.87. This implies that meteorological compartment such as total rainfall doesn't have negative influenced on water quality but instead improve environmental aquatic through dilution of several pollutants. It also indicates the absence of dirty runoff entering the lake during rain as shown by the levels of TSS.
Water Quality Index classification was based on Interim National Water Quality Standard Malaysia which categorized water quality into five classes namely class I (WQI > 92.7), class II (WQI 76.6 – 92.7), class III (WQI 51.9 – 76.5), class IV (WQI 31.0 – 51.9) and class V (WQI < 31.0) based on beneficial use of the water. The calculated values of WQI for all sampling stations (an average of 3 depths) and their classes are shown in Table 3 for both seasons.

Table 3. Mean WQI status in Temenggor Lake

Station	**Wet Season**		**Dry Season**	
	WQI	**INWQS CLASS**	**WQI**	**INWQS CLASS**
SS01	83.00	II	87.41	II
SS02	91.18	II	92.36	I
SS03	83.59	II	76.67	II
SS04	86.04	II	84.03	II
SS05	88.55	II	91.18	II
SS06	91.72	II	91.43	II
SS07	87.50	II	85.44	II
SS08	91.90	II	86.81	II
SS09	93.73	I	91.49	II
SS10	93.88	I	90.95	II
SS11	95.67	I	90.96	II
SS12	95.48	I	94.01	I
SS13	94.12	I	92.59	II
Mean WQI	90.49	II	88.87	II

Table 3 shows that the overall class for Temenggor Lake is class II at both seasons. However with the WQI values very much close to class I, the water quality of the lake can be considered as very clean. Moreover there are stations that already registered as class I in both wet and dry seasons.

As shown in Table 4, the WQI of the lake water seems to change with depths particularly in wet season. While no appreciable change of class recorded in dry season, the water quality changes from class I for surface water to class II for middle level and eventually to class III for bottom layer. This may be due to turbulence cause by heavy rain and its effect on some parameters such as COD and BOD which plat a significant role in the calculation of WQI.

Table 4. Mean WQI values according to depth

Depth	Wet Season		Dry Season	
	WQI	INWQS CLASS	WQI	INWQS CLASS
Surface	93.71	I	91.24	II
Middle	90.63	II	87.57	II
Bottom	75.93	III	81.36	II

Conclusion

The water quality of Temenggor Lake can be considered as clean, in the order of Class II with some stations showing better quality of Class I. This study indicates quite significant seasonal influence of rainfalls on the lake aquatic ecosystems by improving the water quality through dilution effect on to several parameters namely suspended solid, ammoniacal nitrogen, nitrate and phosphate. The study has also shown that the present ecotourism activities (maybe because the intensity is not yet heavy) have minimal impact on water quality except for certain parameters namely ammoniacal nitrogen (mainly from sewage) and oil & grease (from restaurant and boating activities). Surprisingly, no significant increase in oil and grease level was recorded at transport jetty indicating less boating activities during the study. Considering future development of the lake as popular ecotourism destination, the water quality of the lake should be maintained or improved further. An effective management of domestic waste, sewage treatment (namely at Orang Asli settlements, resorts and food outlets), oil & grease (from boating activities), possible soil erosion from open-up of land and logging activities in the vicinity of the lake and organic pollutants (from aquaculture activities namely fish cages) should be planned and enforced. However for the sustainability of the lake, a more integrated approach to the management of the Temenggor Lake based on model of integrated water resource management concept, IWRM should be implemented by all stake holders.

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