Water Quality Status of Pergau Reservoir Water Catchment and Lake, Jeli, Kelantan

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Abstract. A study has been conducted in Pergau Reservoir water intake in Jeli Kelantan. Pergau reservoir is a man-made lake that uses to generate electricity for Kelantan State. Tenaga Nasional Berhad (TNB) was organized the Pergau Scientific Expedition 2019 on 28th October 2019 until 3rd November 2019 in order to check the current status of water catchment of Pergau lake as the intake for the reservoir. In this study, 12 sampling sites was identified by TNB which seven in water catchment area and five stations in lake. During sampling works, water sample were collected for ex-situ analysis and for in-situ analysis, water quality reading was taken using YSI multiparameter. During this study, greater reading was recorded in lake compared to river due to altitude and canopy cover that affect water quality. Greater reading on water turbidity and temperature in lake because affect by natural process and human activity while in river, canopy layer reduces the sunlight penetration. Based on Malaysia Department of Environment, water quality index for both river and lake were identified at 93.3 and 95.1 respectively which classified as clean. Based on this study, clean water quality index will ensure the water safe to be used and environment was healthy.

1. Introduction

Lakes are inland water bodies that lack any direct exchange with an ocean and the ecosystems are made up of the physical, chemical and biological properties contained within these water bodies [1]. Lakes are very important to human for water security storage basin for water supply, agriculture and hydropower. In Malaysia, there are about 90 lakes all around Malaysia and not less than 73 man-made lakes were recorded and were used as water supply, hydro-electric power, irrigation, flood mitigation and others use [2].

Pergau lake is man-made lake located in Jeli district in Kelantan. This lake has form after the construction of Pergau dam for generate electricity. This area is also known as

Pergau Lake Sanctuary Park which encompasses a 460-hectare lake. This area are well known to local community as a fishing spot but has been shut down to people for conservation project by Royal family of Kelantan State. In order to ensure on continuous supply for water generating electricity, a good management of water catchment surrounding the water intake should be implemented. Pollution may affect the quality of river water. Without proper treatment, pollutant especially micropollutant may disturb the purity of river water as mentioned by Amin *et al*. [3-5], micropollutants may not sufficiently removed by conventional sewage treatment.

2. Methodology

2.1 Study Area

Pergau lake situated in Jeli district bordering with Perak state at 5°35'9.90'N 101°44'21.00'E. Pergau Sanctuary also situated near to Perak State Aman Jaya Reserve Forest and Belum-Temengor Reserve Forest Complex. In this studies, seven sampling site involving water intake in river upstream and five point in Pergau lake were identified by TNB as a study site during this Pergau Scientific Expedition as shown in Figure 1. From the seven-sampling site in upstream, six out of seven sampling sites are TNB water intake for Pergau Dam and another one is Pumping station. The upstream sampling sites in river is Suda Intake, Terang Pumping Station, Renyok 1 Intake, Renyok 2 Intake, Renyok 3, Long 1 Intake and Long 2 Intake. In lake, 5 different location was identified by Tenaga Nasional Berhad (TNB) with different characteristic. All river sampling sites are restricted Zones and control by TNB. People are not allowed to enter this area without permission.

2.2 In-situ Water Quality Analysis

In this study, YSI MPS Multiparameter with 10-meter probe has been used to acquire the water quality parameter reading. In each sampling site, 3 replicates of data in each sampling sites were recorded randomly in each sampling site. Water turbidity also measured in field using turbidity meter in sampling sites. Coordinate of each location also taken.

2.3 Ex-situ Water Quality Analysis

For ex-situ water quality, 1500ml water collected at each station and preserved for laboratory analysis. The analysis for biochemical oxygen demand (BOD_5) was done using incubation method, meanwhile the total suspended solid (TSS) was done using gravimetric filtering method. Chemical oxygen demand (COD) and ammonia nitrogen were analysed using Hach Spectrophotometer. Water sample was stored in cool box to maintain the temperature and store immediately in chiller when arrive in laboratory.

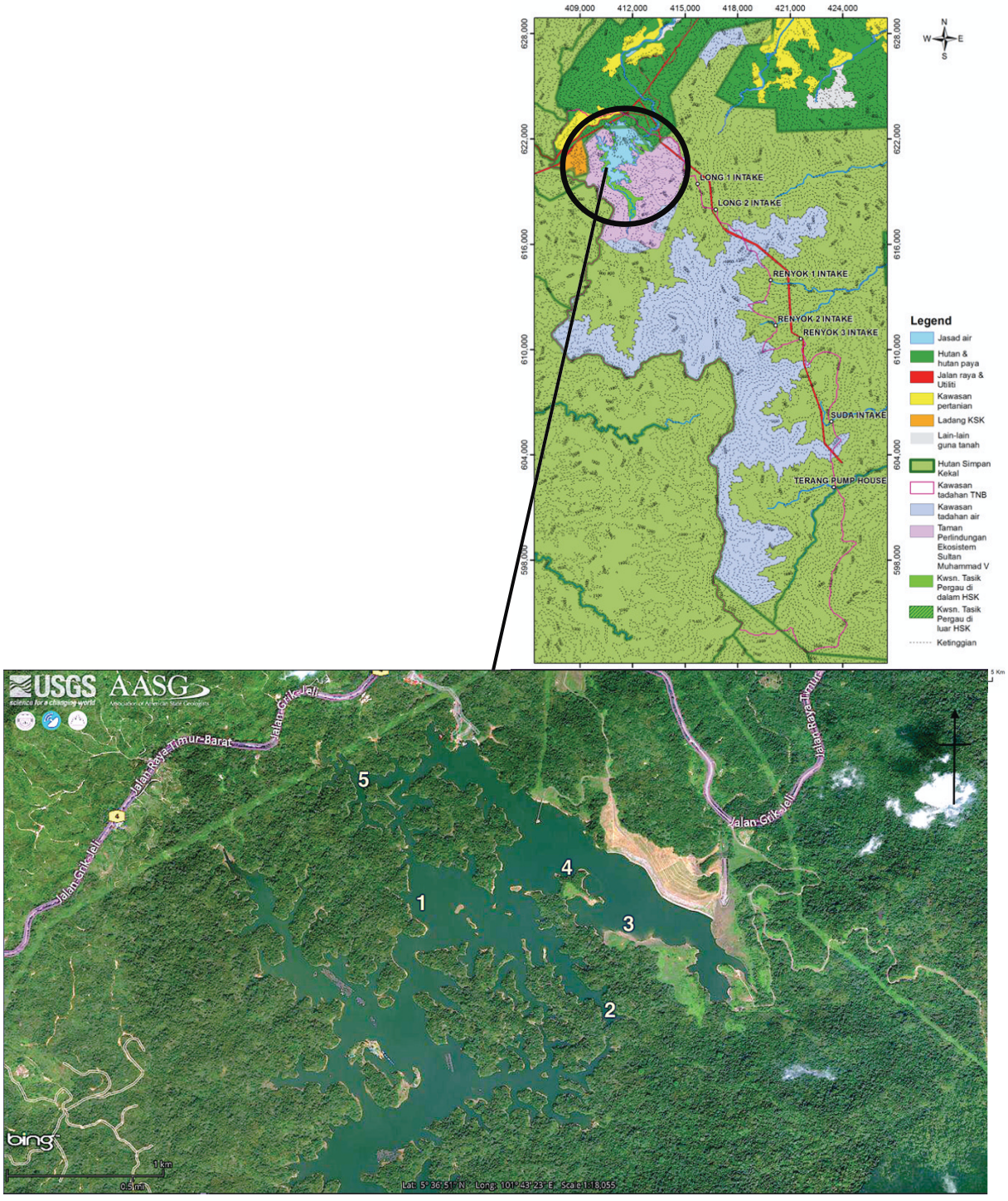

Figure 1. the location of sampling station involves (Source from USGS Maps and TNB)

3. Results and Discussion

3.1 Average Water Quality Parameter in River and Lake

Table 1 show the National Water Quality Standard (NWQS) by Department of Environment of Malaysia to classifies the beneficial uses of the watercourse based on WQI. Table 2 shows the average

of water quality reading in rivers (intake stations) and lake (Pergau lake) in sampling sites. From the result obtained, temperature of river was recorded lower compared to lake due to canopy cover and altitude higher compare to lake. Dissolve oxygen also higher on river due to water turbulence and movement. TDS, conductivity and turbidity also lower in river. Turbidity and BOD recorded lower in river while COD, TSS and Ammoical nitrogen recorded higher in river compared to lake. Conductivity reading was recorded too high due to problem with conductivity meter probe was detected during sampling.

Table 1. National Water Quality Standards for Malaysia (NWQS

National Water Quality Standards For Malaysia							
PARAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/l	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/l	10	25	25	50	100	> 100
Dissolved Oxygen	mg/l	7	5-7	5-7	3-5	< 3	< 1
pH	-	6.5 - 8.5	6-9	6-9	5-9	5-9	-
Electrical Conductivity*	μS/cm	1000	1000	-	-	6000	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-

Table 2. Water Quality Index of water intake and Pergau lake

PARAMETER	**RIVER**	**LAKE**	**NWQS CLASS**
TEMPERATURE	21.50	27.34	1
BRIGHTNESS (lux)	57098.3	57003.6	-
DISSOLVE OXYGEN (mg/L)	7.37	7.3	1
TOTAL DISSOLVE SOLID (g/L)	23.72	19.62	1
CONDUCTIVITY (μS/cm)	20675.64	31540.4	-
Oxidation-Reduction Potential (ORP)	61.43	-38.96	-
pH	6.5	6.43	1
TURBIDITY	1.72	3.85	1
BOD (mg/l)	1.62	2.01	11A
COD (mg/l)	12.69	7	11A, 1
TSS (mg/l)	0.012	0.01084	1
Ammoniacal Nitrogen (mg/l)	0.051	0.046	1

Table 1 shows the National Water Quality Standard (NWQS) for Malaysia by Department of Environment. Table 2 show the result obtained in this study with NWQS rating in each parameter. Based on the result obtained during this study, Temperature, Dissolve Oxygen, Total Dissolve Solids, pH, Turbidity, Total Suspended Solids and Ammoniacal Nitrogen shows NWQS were classified in Class 1. BOD and COD recorded in Class IIA. According to NWQS, Class I water quality are suitable for conservation purpose and the water was practically not needed any treatment for water supply and suitable for any sensitive aquatic flora and fauna. Since 2016, Pergau Lake has been gazetted as a restricted area after The Sultan of Kelantan was announced Pergau lake was Pergau Sanctuary Park. Since the declaration, no any activity of recreational or business within this area and make this area clean and conserved [6]. The objective to announce this area as restricted area due to Department of Fisheries release plenty of fish species.

3.2 Water Quality Index by Location

The water quality index (WQI) shows the rivers and lake have different range as showed in Table 3 and Table 4. The rivers WQI was identified between 91.38 and 96.33, while in the lake WQI identified between 93.83 and 96.2. According to Department of Environment water classification based on water quality index showed that WQI index range in all sampling locations was clean in the range of 80 to100. According to Karmakar and Mavukkandy [7], most of the lakes and reservoirs globally face environmental stress, and the appropriate functioning of various vital ecosystems is in danger. Pollution from agricultural lands and from domestic may produce eutrophication undesirable effects such as the presence of toxic algae, reduction of oxygen, and generation of unpleasant odour. The proliferation of contaminants within lake and reservoir systems can deteriorate water quality significantly. If compared to water intake stations, there are less human disturbance by human activities due to that area was been gazette as restrict area by TNB.

Table 3. Water quality index in sampling sites.

SAMPLING SITES	WQI	INDEX RANGE (Based on Malaysia WQI)
Terang Pumping Station	91.89	Clean (81-100)
Suda Intake	92.4	Clean (81-100)
Renyok 3 Intake	91.38	Clean (81-100)
Renyok 2 Intake	91.38	Clean (81-100))
Renyok 1 Intake	95.85	Clean (81-100)
Long 1 Intake	93.9	Clean (81-100)
Long 2 Intake	96.33	Clean (81-100)
Lake Point 1	93.83	Clean (81-100)
Lake Point 2	96.2	Clean (81-100))
Lake Point 3	95.63	Clean (81-100)
Lake Point 4	95.66	Clean (81-100)
Lake Point 5	94.71	Clean (81-100)

Water temperature generally recorded higher in lake compared to river. But, in lake, different depth shows different temperature reading due to surface water temperature was affect by sunlight. This situation also known as thermal stratification that lakes break into different layers of density due to differing temperatures. According to Pafard [8], thermal stratification occurs when the water in a lake forms distinct layers through heating from the sun that often only penetrates a few metres into the lake, directly warming just the top few metres. As the water warms, it becomes less dense and remains at the surface, floating in a layer above the cooler, denser water below.

Average dissolve oxygen of water intake and Pergau Lake were recorded at 7.33 mg/L. Deeper lake depth show dissolve oxygen level decrease significantly compared to surface layer of the lake and shallow river. According to Pafard [8], The shallowest layer is that warm surface layer, called the epilimnion is the layer of water that interacts with the wind and sunlight, so it becomes the warmest and contains the most dissolved oxygen. Although dissolved oxygen does not play a direct role in lake stratification and turnover, it is important for all the aquatic organisms in a lake that require oxygen to survive.

Total dissolve solids were recorded highest in lake point 3 in 10 meters deep. This s may happen due to the point 3 is located near dam that sediments and organic particles accumulate in that area near to water outlet. Fiona-Annilow *et al*. [9] mentioned that water quality near the dam spillway affect the water quality in particulate area and also affects the conductivity.

Table 4. Water quality parameter in each sampling sites.

Site	TERANG PUMPING STATION	SUDA INTAKE	RENYOK 3 INTAKE	RENYOK 2 INTAKE	RENYOK 1 INTAKE	LONG 1 INTAKE	LONG 2 INTAKE	LAKE POINT 1			LAKE POINT 2			LAKE POINT 3			LAKE POINT 4			LAKE POINT 5			STDEV	AVERAGE
Depth (Meter)								1	5	10	1	5	10	1	5	10	1	5	10	1	5	10		
COORDINATE	5°26.6250'N 101°48.0590'E	5°26.6250'N 101°48.0590'E	5°31'9.50'N 101°46'56.30'E	5°31'37.00'N 101°46'12.90'E	5°33'0.10'N 101°46'3.10'E	5°35'58.00'N 101°43'6.50'E	5°35'12.20'N 101°44'21.10'E	5°36'56.50'N 101°41'6.30'E			5°36'38.30'N 101°41'39.80'E			5°37'18.30'N 101°41'51.50'E			5°37'45.50'N 101°41'12.40'E			5°37'45.50'N 101°41'12.40'E				
RIVER CANOPY/ AREA CHARACTERISTIC	OPEN IN LOWER AND CANOPY SLIGHTLY COVER THE RIVER	COVERED AREA	COVERED AREA BY TREE CANOPY	OPEN AREA	OPEN AREA	COVERED AREA	COVERED AREA	Between Pulau Kesedar & Pulau TNB			Near to small stream, water inlet to lake (East)			Near to dam			Near to small stream, water inlet to lake (West)			Near to small stream, water inlet to lake (West)				
ALTITUDE (METER)	587	623	663	673	686	755	674	616			616			616										
TEMPERATURE (°C)	22.86	22.35	20.74	21.11	21.73	20.94	20.8	27.26	26.14	25.49	27.53	26.59	25.74	27.77	26.18	24.81	27.29	25.89	25.48	26.87	25.76	25.53	2.43	24.77
BRIGHTNESS (lux)	25146.5	5685	104418	125794.6	103049	19629	15966	119866			116346			28472			15343			4991			50952.79	57058.84
DISSOLVE OXYGEN (mg/L)	7.96	7.19	7.27	7.53	7.28	6.65	7.73	7.54	3.96	0.52	7.61	4.99	0.16	7.19	0.59	0.07	7.37	0.44	0.17	6.81	0.32	0.27	3.38	4.53
TOTAL DISSOLVE SOLID (g/L)	13.09	14.13	12.71	11.78	15.28	83.23	15.84	19.78	20.65	20.8	19.57	20.24	26.44	19.65	21.48	90.19	19.45	20.89	20.37	19.67	30.03	34.6	20.43	25.90
CONDUCTIVITY (μS/cm)	19317.83	20649	17964.5	15941.12	22044	26397.67	22415.33	31739	32470	32397	31566	32083	41256	31828	33788	38250	31231	32685	31636	31338	46863	53768	9155.57	30801.25
Oxidation-Reduction Potential (ORP)	74.05	69.67	111.52	111.85	47.87	15.17	-0.083	-48.3	-24.4	-42	-38	-9.8	-86.2	-38.8	-28.1	-146.6	-36.8	-8	-59.4	-32.9	-96.7	-122	68.55	-17.63
pH	6.36	6.47	6.12	6.31	6.83	6.34	7.04	6.6	5.75	5.6	6.42	5.65	5.6	6.47	5.32	5.9	6.55	5.36	5.52	6.1	5.66	5.81	0.49	6.08
TURBIDITY	3	1.78	1.66	1.37	0.97	1.97	1.3	3.77			3.77			3.98			3.27			4.45			1.22	2.61
BOD (mg/l)	0.92	1.56	2.675	1.62	1.765	1.22	1.56	1.63			2.56			1.65			1.43			2.79			0.59	1.78
COD (mg/l)	31.5	19.5	13.5	11	6	2	2	16			2			3			8			6			8.94	10.04
TSS (mg/l)	0.016	0.015	0.009	0.0116	0.0153	0.0173	0.0124	0.00067			0.01089			0.01533			0.01022			0.01711			0.0047	0.013
Ammoniacal Nitrogen (mg/l)	0.02		0.09	0.01	0.01	0.1	0.08	0.05			0.03			0.07			0.05			0.03			0.032	0.049
WQI	91.89	92.4	91.375	91.375	95.85	93.9	96.33	93.83			96.2			95.63			95.66			94.71			0.94	95.206

The turbidity river water and lake in sampling sites was identified at 1.72 NTU in river and 3.85 NTU in lake. Based on NWQS, turbidity in both river and lake was in Class 1. Compared to lake, water was affected by surrounding affect by human activities and natural process and algae. According to Yuk *et al*. [10], water quality in lake as well as turbidity can be influenced by external inputs entering the lake from the watershed as well as the in-lake ecosystem, nutrients cycling and internal loading. Total suspended solids were recorded higher in river due to water turbulence in ripple of upstream. Lake was more stagnant which particulate matter and sediment settle to the lake bottom.

4. Conclusion

From this study, the water quality of all sampling sites was classified as clean based on Water Quality index by Department of Environment of Malaysia. NWQS also shows almost all parameters recorded during this study was in Class 1. Clean water will ensure the water availability to support water reservoir that needed to generate electricity and consumer use. Since no any recreational and any human activity in Pergau lake due to restriction by state government, this make Pergau lake clean and sustained. Besides that, continuously monitored by TNB in upstream especially in water intake has sustained the nature of upstream area to ensure water continuously can be supplied to the reservoir. Proper management of water catchment will be value added to keep it sustained and continuously supply us good quality water.

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