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Comparative Water Quality Analysis Between Tahan River and Sat River in Taman Negara Pahang, Malaysia

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Rivers, particularly in national parks like Taman Negara Pahang, play an important role in sustaining aquatic life forms, besides the livelihood of the locals. In conserving the area, particularly in observing the tributary locality effects unto upstream and downstream of the Tembeling River, water quality study has been carried out in two tributaries, namely, Sat and Tahan. Sampling was conducted at eight sampling locations for each river, and the parameters analysed were temperature, pH, Total Suspended Solids (TSS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and ammoniacal nitrogen (AN). Results were then used in calculating the rivers' WQI-DOE water quality indices. In comparison, through the WQI-DOE indexing, overall, the Tahan River scored slightly lower than the Sat River by obtaining the water quality of Class II, while the Sat River was of Class I. The one-way Analysis of Variance (ANOVA) with a confidence level of 95% showed that all water quality parameters measured exhibited no significant differences between the sampling stations locality. Thus, indicating that the locality of the rivers does not interfere with the water quality readings obtained.

Key words: Water Quality; Taman Negara Pahang; Sat River; Tahan River; WQI-DOE Index

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Taman Negara National Park is the oldest and largest protected area located in the central region of Peninsular Malaysia [1]. It is one of the world's most complex and richest ecosystems [2]. It is also one of the main regions that contribute to the richness of wildlife in Peninsular Malaysia [3],[4], [5],[6]. It has a wide range of habitat types, such as lowland that consists of riverine vegetation, hill dipterocarp forest, lower and upper montane forest, heath forest, and riparian forest [7].

There are many rivers that can be found in Taman Negara Pahang, all of which are the tributaries of the Tembeling River. The Tembeling River acts as the boundary for Taman Negara Pahang and the non-conservated area, which locates the local villages in the area. In this study, two Tembeling tributaries in Taman Negara Pahang, the Tahan River and Sat River, were selected as the Tahan River is near Kuala Tahan, the busiest locality in Taman Negara, while the Sat River is one of the upstream tributaries. Both rivers, however, are known for good fishing and recreational location. Although the rivers in Taman Negara serve as a recreational attraction, very few studies were conducted pertaining to the water quality of the area, and recent studies were scarce [8]. Therefore, there is a need to establish a current database on the water quality for these rivers to ensure the sustainability of the area, particularly the ecosystem and the Taman Negara visitors. As such, the main objectives of this study were to determine the quality of the Sat River and Tahan River according to the WQI-DOE Index and classify the rivers according to the National Water Quality Standards for Malaysia (NWQS).

Department of Environment, Malaysia has set a water quality index (WQI-DOE) and the National Water Quality Standards (NWQS) as a basis for classification of water quality. Six water quality parameters are used to determine the level of water quality in the water quality indexing calculation, namely, dissolved oxygen (DO), pH, total suspended solids (TSS), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), and ammoniacal nitrogen (NH_3-N). With the results of WQI calculation, studied river systems will be classified into Class I to Class V. Class I indicates a good water quality, and the quality declines as the class increases.

MATERIALS AND METHODS

Study Sites and Experimental Design

Eight sampling locations for each river, Sat and Tahan were determined as in Figure 1. Sampling was conducted using the grab sampling method at approximately 30 cm beneath the water surface. Stations 1, namely S1 and T1 for Sat and Tahan, respectively, were upstream of the rivers, while

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Stations 8 (S8 and T8) were downstream. The location of each sampling area is presented in Table 1. Water samples were collected in triplicate using a grab sampler and preserved following the APHA preservation method [9].

Parameters studied were water temperature, pH, dissolved oxygen, total suspended solids, biochemical oxygen demand, chemical oxygen demand, and ammoniacal nitrogen. *In situ* parameters like temperature, pH, and dissolved oxygen were measured using YSI multi parameter probe 556MPS, while the other parameters like total suspended solids, biochemical oxygen demand, chemical oxygen demand, and ammoniacal nitrogen were conducted *ex situ* in the laboratory. Total suspended solids (SS) values were obtained via gravimetric method. Biochemical oxygen demand (BOD_5) analysis was conducted using a 5-day BOD test [9]. While chemical oxygen demand (COD) and ammoniacal nitrogen (NH_3-N) analysis were done using HACH 2800 spectrophotometry method.

Obtained analysis results were then used to calculate the WQI-DOE index to assess the state of the sampling locality water quality. The WQI produces an indicative value, and this value was compared to the standard given. As a result, the rivers or streams can be estimated for their quality. Water quality data obtained were used to calculate the subindex and WQI index. The formula used for WQI calculation is shown in Eq.1:

$$WQI = 0.22(SIDO) + 0.19(SIBOD) + 0.16(SICOD) + 0.15(SIAN) + 0.16(SISS) + 0.12(SIpH) - \quad \text{Eq.1}$$

where;
SIDO = Subindex DO (% saturation), SIBOD = Subindex BOD_5, SICOD = Subindex COD, SIAN = Subindex NH_3-N, SISS = Subindex SS and SIpH = Subindex pH

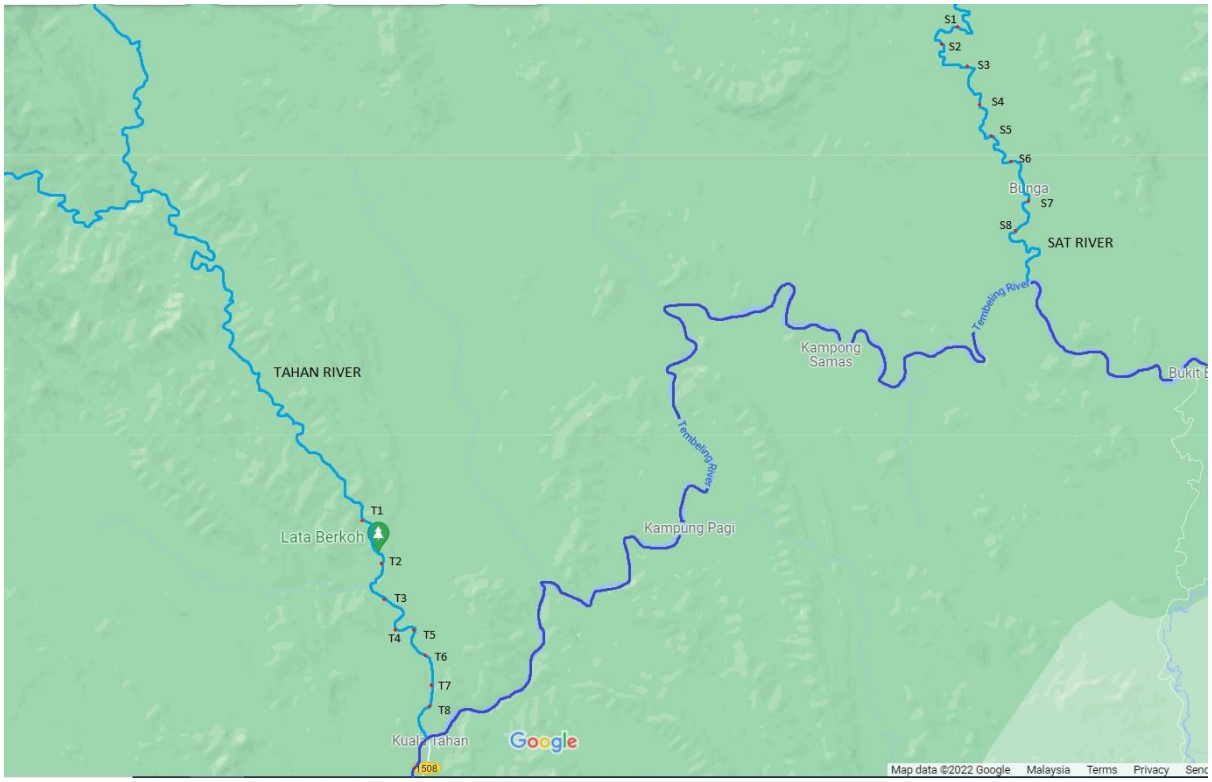

Figure 1. Map of Sat River and Tahan River in Taman Negara Pahang. Map source: Google Map

Table 1. Sampling locations of Sat River dan Tahan River

Station	Sat		Station	Tahan	
	Longitude	Latitude		Longitude	Latitude
S1	N 04°37.1932'	E 102°33.9663'	T1	N 04°44.0839'	E 102°38.6528'
S2	N 04°36.5631'	E 102°34.2029'	T2	N 04°43.1731'	E 102°38.2854'
S3	N 04°36.0655'	E 102°33.5143'	T3	N 04°42.5489'	E 102°38.9368'
S4	N 04°35.5861'	E 102°34.1857'	T4	N 04°41.7649'	E 102°39.0904'
S5	N 04°35.5400'	E 102°34.3621'	T5	N 04°41.8130'	E 102°39.5935'
S6	N 04°35.0765'	E 102°34.4450'	T6	N 04°41.3745'	E 102°39.5711'
S7	N 04°33.9477'	E 102°34.8939'	T7	N 04°40.8118'	E 102°40.1510'
S8	N 04°33.8059'	E 102°34.8675'	T8	N 04°39.2476'	E 102°40.0734'

Note: Weather during the sampling exercise was clear for both rivers

Statistical Analysis

The Sat River is located upstream of the Tembeling River, while the Tahan River is downstream. In determining the presence of significant differences among water quality parameters and the sampling station locality, statistical analysis that has been used in this study was a one-way Analysis of Variance (ANOVA) with $\alpha = 0.05$ and confidence level at 95%. Data obtained were analysed using Minitab software and Microsoft Excel.

RESULTS AND DISCUSSION

The results obtained from this study were statistically analysed and compared to the values of the National Water Quality Standards (NWQS) using the WQI-DOE indexing.

1. Physical Parameters

1.1. Temperature

Figure 2(a) shows temperature varied from 25.14°C to 26.28°C in the Sat River and 24.93°C to 27.28°C in the Tahan River. These readings indicate that both rivers are in the range of Class I in accordance with the NWQS. The analysis of ANOVA for the Sat and Tahan rivers has no significant differences in the temperature readings with the p-values of 0.65881 and 0.55892, respectively. The Sat River indicated higher water temperature due to its water depth, in agreement to Idris *et al*. (2005) that higher temperature is basically due to the shallowness of the river, also the slow flow rate of the river approaching downstream, as can be observed at S8 of the Tahan River [10].

1.2. pH

Figure 2(b) shows the pH value in the range of 6.40 to 7.07 for the Sat River and 6.32 to 7.33 for the Tahan River. No significance value was observed in the analysis of ANOVA with the p-values of 0.84869 and 0.77445 for the Sat and Tahan rivers, respectively. Freshwater can vary in acidity and alkalinity caused by natural factors and man-made inputs [11]. The pH of a river will affect what types of organisms can live in the river, and pH 6.5 to 8.2 is optimal for most organisms [12]. Sat and Tahan readings were in the optimum range for the river organisms to sustain.

1.3. Total suspended solids (TSS)

Total suspended solids in the Sat River ranged from 7 mg/L to 13 mg/L, while in the Tahan River 11 mg/L to 21 mg/L (Figure 2(c)). Both rivers indicated as Class I rivers for the TSS reading based on the NWQS. ANOVA analysis showed no significance in its readings with the p-values of 0.34565 and 0.47258 for the Sat and Tahan rivers, respectively. Total suspended solids refer to small solid particles which remain in suspension in water as a colloid or due to the motion of the water. High TSS can cause an increase in surface water temperature because the suspended particles absorb heat from sunlight and can cause dissolved oxygen levels to fall [13], as supported by the findings obtained from this study (Figure 3(a)), where dissolved oxygen levels were low at S5 and S8 of the Tahan River.

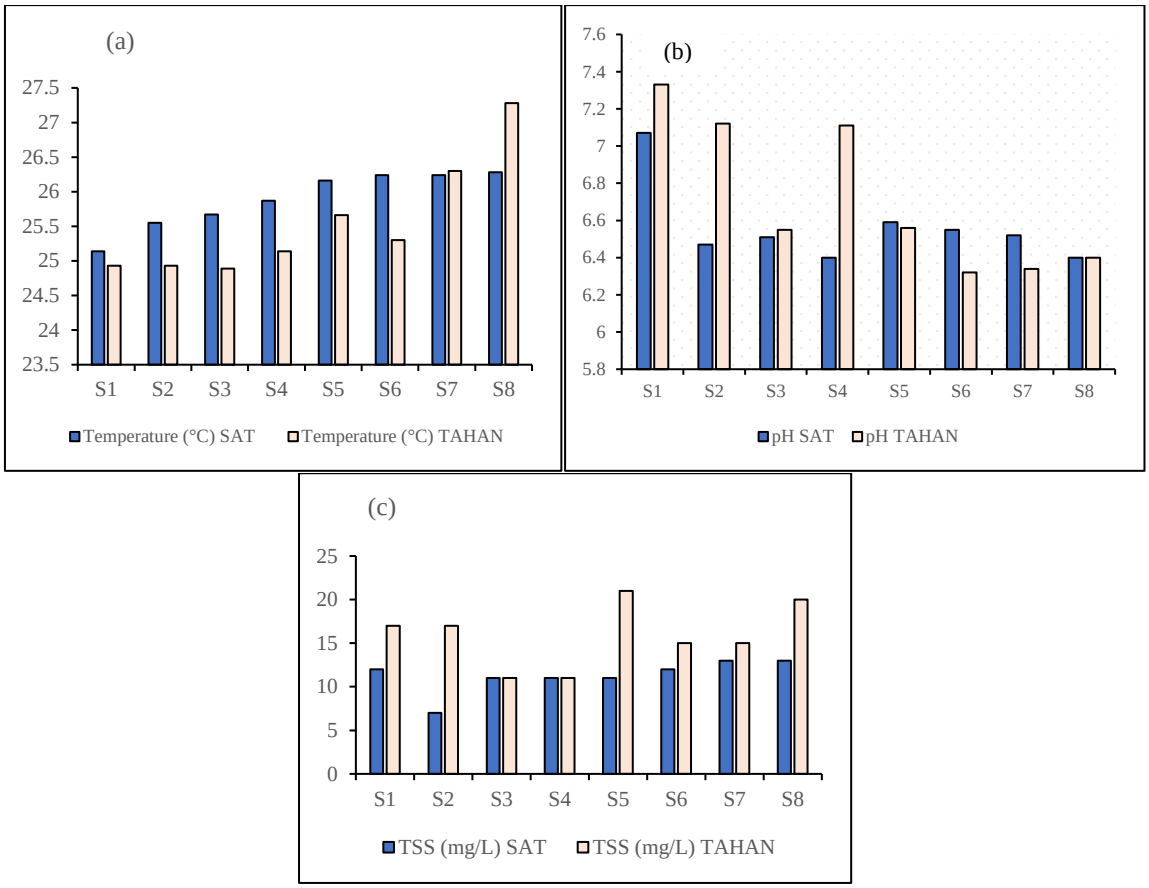

Figure 2(a-c). Physical parameter results obtained from Sat River and Tahan River; (a) Temperature, (b) pH and (c) Total suspended solids (TSS).

Chemical parameters

1.4. Dissolved Oxygen (DO)

Dissolved oxygen in the Sat River recorded a range of 7.9 mg/L to 9.15 mg/L, while the Tahan River 6.85 mg/L to 8.08 mg/L (Figure 3(a)). Under the NWQS, the Sat River readings were all of Class I, while in the Tahan River, stations S5 and S8 were of Class II with 6.96 mg/L and 6.85 mg/L, respectively. However, ANOVA analysis for the Sat and Tahan rivers showed no significance with the p-values of 0.24898 and 0.33215, respectively. Dissolved oxygen refers to the amount of oxygen available in water, which is determined by level of turbidity, suspended particles, and population of organisms in the area [14]. It is always higher upstream and gradually drops to a lower level when the water quality deteriorates due to various factors [15]. The main cause of oxygen depletion is the oxidation material in the water body [16], as clearly demonstrated by high values of suspended solids observed in the Tahan River stations S5 and S8 (Figure 2 (c)).

1.5. Biochemical Oxygen Demand (BOD_5)

BOD measures of the amount of organic material that decomposes biochemically in water and serves as an indicator of pollution by organic substances. When there are low levels of organic waste in water, fewer bacteria are present, the BOD will be lower, and the dissolved oxygen levels are higher [17]. Figure 3(b) illustrates the biochemical oxygen demand readings for the Sat and Tahan rivers. The Sat River recorded Class I readings for its biochemical oxygen demand analysis except for S3 and S6, where the readings for these stations were of Class II with the concentration of 3.45 mg/L and 3.31 mg/L, respectively. On the other hand, the Tahan River recorded Class II readings for its biochemical oxygen demand and Class III for stations S5 and S8, with the readings of 6.58 and 6.22 mg/L, respectively. The findings agree with the DO readings from the study, wherein both stations, S5 and S8, the DO readings (Figure 3(a)) were the lowest. When analysed statistically, no significant difference was observed in all readings obtained for the Sat and Tahan rivers, with the p-values of 0.84970 and 0.84869, respectively.

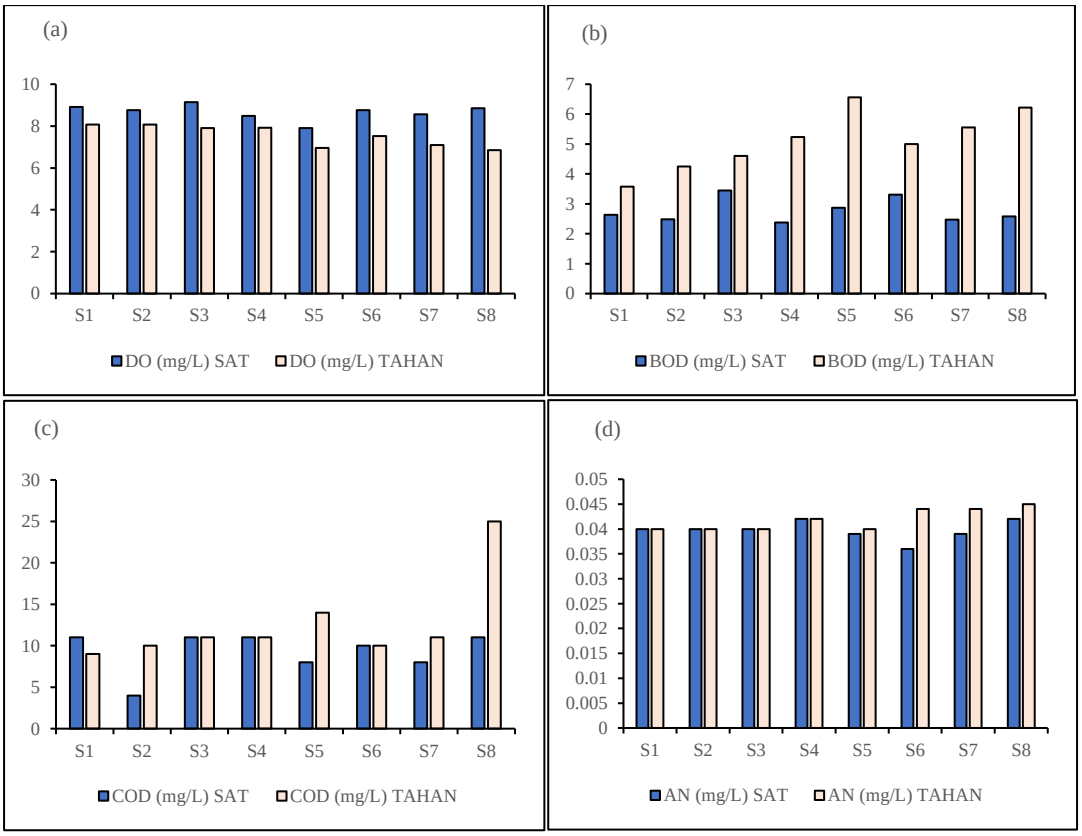

Figure 3 (a-d). Chemical parameter results obtained from Sat River and Tahan River; (a) Dissolved Oxygen, (b) Biochemical Oxygen Demand (BOD_5), (c) Chemical Oxygen Demand (COD) and (d) Ammoniacal Nitrogen (NH_3-N).

1.6. Chemical Oxygen Demand (COD)

Figure 3(c) illustrates the chemical oxygen demand readings for the Sat and Tahan rivers. Both rivers recorded Class I readings for all stations except station S8 of the Tahan River, with the reading of 25 mg/L (Class II). However, ANOVA analysis for the Sat and Tahan rivers showed no significance with the p-values of 0.14245 and 0.23576, respectively. High COD indicates deterioration in water quality. The rapid movement of river water and high organic matter content will affect COD reading. However, dilution of organic substances by the high volume of water will reduce the concentration of COD in stream water [18], which explains the low concentration of COD in the rivers except for S8 of Tahan, which is downstream and near to Kuala Tahan.

1.7. Ammoniacal Nitrogen (NH_3-N)

Ammoniacal-nitrogen is the main indicator present in animal and human waste, domestic waste, urban and industrial, as well as agricultural fertilisers. Typically, the natural water content of ammonia is less than 0.1 mg/L. Figure 3(d) shows that all sampling stations in Sat and Tahan respectively attained Class I readings in the ammoniacal nitrogen analysis, with all readings below 0.1 mg/L, as stated in the NWQS. Statistical analysis showed no significant difference p-value of 0.14527 and 0.25474, respectively, for Sat and Tahan.

2. National Water Quality Standards (NWQS)

Figure 4 illustrates the National Water Quality Standards (NWQS) for the Sat and Tahan rivers. For the Sat River, all its stations (S1-S8) were of Class I, as the readings for the WQI-DOE were all above the 92.7 mark, which is the limit for Class I rivers, with the range of 93 to 95 and an average of 93.5. Thus, the Sat River is a Class I river, which under the NWQS is a natural conserve environment with very sensitive aquatic species, and no treatment is required for its water supply. The Tahan River, on the other hand, falls under the Class II river, with the range of WQI-DOE index of 85 to 92 and an average of 89.25. A Class II river like Tahan is home to sensitive aquatic species and is suitable for water recreations. Although it is suitable for water recreational activities, the deterioration of the water quality may be due to the interference related to human activities like land development and recreational activities [19], [20]. Thus, in ensuring the sustainability of the preserved watershed, a more effective land-use planning method that considers the impact of the development needs to be addressed.

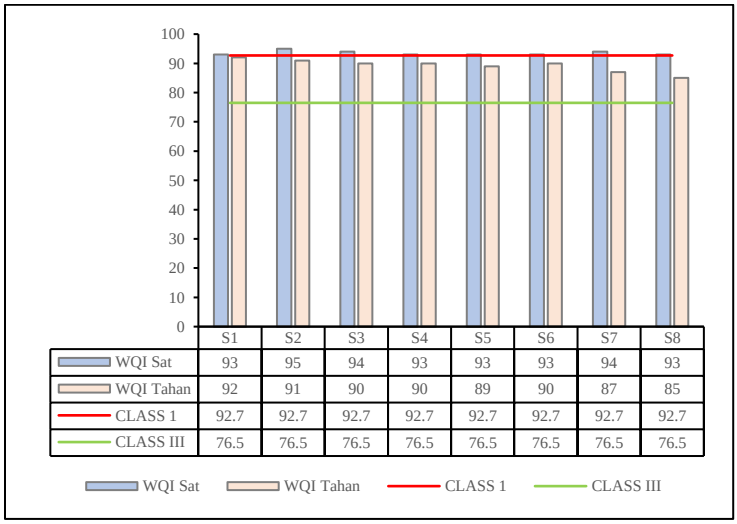

Figure 4. National Water Quality Standards for Sat River and Tahan River

CONCLUSION

In conclusion, based on the WQI-DOE and the NWQS results from the study, the Sat River is classified as a Class I river with an average WQI-DOE index of 93.5. Thus, it is considered as a natural conserve environment with very sensitive aquatic species, and no treatment is required for its water supply. The Tahan river, on the other hand, falls under the Class II river with an average WQI-DOE index of 89.25. A Class II river like Tahan is home to sensitive aquatic species and is suitable for water recreations. Statistical analysis conducted was not significantly significant as both rivers, although are the tributaries of Tembeling, do not have a significant result based on the p-values obtained, due to the morphology of both rivers, as Sat is fast flowing with rapids, while Tahan is slow flowing with fewer rapids. In preserving the rivers from contamination and deterioration due to improper practices of businesses and tourists, it is recommended to conduct regular water quality assessment to conserve the water quality of the area, besides educating visitors on the importance of sustaining the cleanliness of the site, as Taman Negara Pahang is one of the national heritage that needs to be ensured its sustainability.

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