Assessment of Water Quality and Landuse using QGIS at the Tasik Chini : Implications for Environmental Management

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Abstract. This study investigates the water quality and landuse at the Tasik Chini, Pahang, Malaysia. Recently, water quality and biodiversity of the Tasik Chini was significantly deteriorated due to the mining and agriculture activities nearby the Tasik Chini. The water quality was significantly deteriorated by the metals from the mining area and high consumption of fertilizer from the agriculture activities. Therefore, this study was significantly urgent to determine the water quality and to characterize the type of landuse at this lake. The assessment of the water quality was conducted at in-situ and laboratory experiments. Samples of water were collected at Laut Kenawar, Laut Serodong, Laut Gumum, Batu Busuk and Jeti UKM. Measurements of dissolved oxygen, pH, ammoniacal nitrogen, chemical oxygen demand, biochemical oxygen demand, total suspended solids, and metals were conducted in this study. Land use analysis was performed using QGIS to determine the type of landuse. The dominance landuse are forested area (69.48%), followed by agriculture area (9.69%) and mining area (9.60%). The water quality analysis shows that the water quality index of the Tasik Chini was dominantly under Class (III). The concentration of dissolved oxygen was significantly low and the existence of Fe, Cu and Al significantly deteriorated the water quality of the Tasik Chini. Therefore, suitable mitigation measures are required to preserve the water quality and biodiversity of this lake. The findings from this study could provide better environmental management to control landuse development and sustain the water quality of the Tasik Chini.

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1 Introduction

Water is a fundamental necessity and source of life for all creatures on Earth, serving not only as a source of drinking water but also as a basis for maritime food sources. Globally, however, many countries, especially developing and underdeveloped ones, face challenges in accessing water resources due to inadequate infrastructure and declining water quality. Malaysia is not exempt from water pollution issues due to the rapid development that increased source of pollution (e.g., point source and non-point source). For example, Kim-Kim River was heavily polluted due to the illegal chemical wastes dumped into the river in 2019 and significantly affect the water quality and the biodiversity of the river (Yap et al., 2019). Malaysia also rich with natural and man-made lakes. Tasik Chini is the second largest natural lake in Malaysia, and it is recognized as a UNESCO Biosphere Reserve, encompassing 6951 hectare and rich with diverse flora and fauna. The lake and its surrounding areas, including Sungai Chini and Bukit Chini, are vital to the local Jakun tribe, providing food and livelihood. However, Tasik Chini is sensitive to pollutants from various sources (e.g., mining and agriculture activities) (Adilah & Nadia, 2020), necessitating vigilant water quality monitoring to preserve its ecological balance and support the community that depends on it.

Referring to the literature, the expansion of oil palm plantations near the lake's margins has posed serious threats to water quality (Abdusalam Y. H. et al., 2019). Mining activity is also one of the main factors that decreased the water quality of the Tasik Chini. This mining area is located at the Bukit Kebaya and Bukit Chini, which is the high gradient points of the lake. Therefore, contaminated runoff with metals was significantly contaminated the lake and caused sedimentation and riverbank deterioration (International Co-ordinating Council of the MAB Programme, 2021). Previous study also has reported that the income of fishermen at this lake was significantly decreasing due to the polluted water from the inadequate wastewater treatment facilities from the local village, the usage of agrochemical from the agriculture activity and pollutant run-off from the mining area (Abidin et al., 2021). Urbanization and agricultural expansion also have led to increase runoff and sedimentation, further degrading the water quality (Abdusalam et al., 2017). Due to this reason, villagers must seek alternative jobs, such as tapping rubber and farmer (Alagesh, 2019). Therefore, this study urgently aims to monitor the current water quality of the Tasik Chini in relation to land use activities. The finding of this study significantly for long-term preservation of the aquatic life and biodiversity of the Tasik Chini.

2 Methodology

2.1 Sampling Area

The water samples were collected from five (5) points (e.g., Laut Kenawar, Laut Serodong, Laut Gumum, Batu Busuk and Jeti UKM) marked as station A, B, C, D and E (Figure 2.1). The water samples (500 mL) were stored in the plastic bottle and preserved in an ice box to contain it at low temperature before transferred to the laboratory for testing purposes. For the water quality analysis, the experimental work was conducted at the Environmental Laboratory 1, Block 1, School of Civil Engineering, College of Engineering, UiTM Shah Alam. For the water quality analysis, eight (8) main parameters were measured, including dissolved oxygen (DO), pH, ammoniacal nitrogen (NH_3-N), chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solids (TSS), and metals (e.g., iron (Fe), aluminum (Al) and copper (Cu))

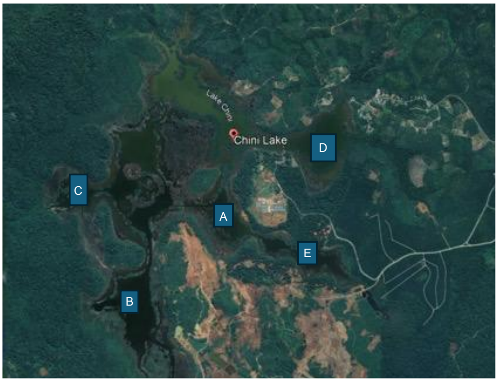

Figure 2.1: Location of Sampling at Tasik Chini

2.2 In-situ Measurement

In-situ measurement focus on the measurement of DO and pH by using the Horiba. The Horiba device was turned on by gently pressing the POWER button. After using clean water to clean the surface detector of the Horiba, the Horiba was calibrated. The probe was lowered to the required (e.g., 1 m from the surface of water) at the selected sampling location to measure the pH and the DO. The probe was carefully inspected to make sure it was completely immersed and free of bubbles. After pressing the MEAS button, the reading was permitted to stabilize. The data was recorded when it stabilized.

2.3 Experimental Work

Experimental works focus on the measurement of the TSS, BOD, COD, NH_3-N, Fe, Al and Cu. After the sampling process, water samples were transported to the laboratory to analyze the water quality of the lake. Determination of the BOD and COD were referred to the HACH DR2800 method in line with the Nessler method according to HACH (2007). All the samples were measured using DR2800 Spectrophotometer. The

TSS was measured using DR2800 Spectrophotometer. The wavelength of TSS was set at 630mm. Blank sample was prepared by using the DIW. 10 mL of the DIW was poured into the glass cell, the outer surface of the glass cell was cleaned with tissue to avoid error during the measurement and inserted it into the cell holder. Then, 10 mL of water sample was poured into the glass cell and followed the same procedures as mentioned above. According to the HACH (2007), the COD was measured using The Reactor Digestion Method. The water samples were poured into the glass bottle containing potassium dichromate (oxidizing agent). Turn on the DRB2000 reactor and preheat to 150°C. 100 mL of samples (100 mL) required to be homogenized for 30 sec by using blender. If the samples containing large amounts of solids, increased the homogenization time. Then 2.0 mL of sample was transferred into the vials. Vials need to be capped and cleaned the outside of the vial. Then hold the vial and mixed the sample by inverted the vial gently several times. Placed the vial in the preheated DRB200 reactor and closed the protective lid. The samples need to be heated for two (2) hours at 150 °C. Then, wait for 20 mins for the vial to cool to 102°C or less and inverted the vials several times while it still hot. Placed the vial into the rack to cool to room temperature. Then, insert the vial into the cell holder of DR2800 Spectrophotometer to measure the concentration of COD. Procedures to measure BOD is referred to the HACH standard (2007). The collected samples from the lake were placed in the incubator at temperature 20°C. Prepared 1L solutions of ferric chloride ($FeCl_3$) (0.75g), calcium chloride ($CaCl_2$) (27.5g), and sulphate (22.5g). Phosphate buffer solution was prepared using monopotassium phosphate (K_2HPO_4) (124.9 mM), sodium phosphate (Na_2HPO_4 $7H_2O$) (124.6mM), and ammonium chloride (NH_4Cl_2) (60 mM). Nutrient solution was prepared by using dilution method (1:1000), each solution above was diluted in 1L of DIW. Then, 100 mL of water sample was mixed with the 200 mL nutrient solution. Initial concentration of dissolved oxygen (DO_i) was measured using DO meter. After 5 days of incubation the final measurement of DO (DO_f) was measured. Water Quality Index (WQI) was calculated using guideline provided by DOE. The calculation of the WQI consists of six (6) sub-index values as below (Eq. 1). The value of each parameter was compared with the standard National Lake Water Quality Criteria and Standard (NLWQS) under category C in Table 2.1.

$$WQI = (0.22 \times SIDO) + (0.19 \times SIBOD) + (0.16 \times SICOD) + (0.15 \times SIAN) + (0.16 \times SITSS) + (0.12 \times SIpH) \quad (1)$$

Table 2.1. Parameters of Category C in NLWQS

Parameter	Unit	Category C
DO	**%**	55-130
pH	**-**	6.0- 9.0
TSS	**mg/L**	200
Turbidity	**mg/L**	70
COD	**mg/L**	6
BOD	**mg/L**	25

NH_3-H	**mg/L**	1[a]

To measure concentration of Cu, a CuVer® 1 Copper Reagent Powder Pillow was transferred into a square sample cell containing 10 mL of the sample and wait for two minutes. The DR 2800 Spectrophotometer was then calibrated and started program 135 Copper, Bicin. The samples showed a purple color when Cu in the sample mixed with the reagent powder. Prepared the blank samples and filled a second samples cell with 10 mL of samples and insert the blank into the cell holder and start measurement. Ascorbic acid and AluVer 3 reagent were used to prepare the sample for Al. Prepare th samples and waited for 15 minutes. Blank samples were also prepared for this Al measurement. For the Fe, the sample was mixed with a FerroZine® Iron Reagent Solution Pillow. Samples were prepared and waited for five minutes. Then, observed the color changed. The blank and prepared samples were measured using the 260 Iron FerroZine test. For each metal measurement, the blank was first placed into the cell holder, pressed button ZERO, followed by the prepared sample, and the results were displayed in mg/L of the respective metal (e.g., Cu, Al and Fe).

2.4 GIS analysis of landuse

A thorough technique to identify land use patterns and possible sources of pollution is made possible by combining Quantum Geographic Information Systems (QGIS) software with Google Earth's satellite images for the visual classification of land use categories. With the visual interpretation of satellite imagery, Google Earth was used to identify different type of land use, such as industrial, residential, agricultural, and natural regions from current sky view in the area (refer to Figure 2.2 (a-b)). This data is incorporated into QGIS software, which overlays further layers to improve spatial analysis, including administrative borders and pollution sources (refer to Figure 2.3). Percentage of different types of land use were calculated and computed using combination of QGIS method and Google Earth

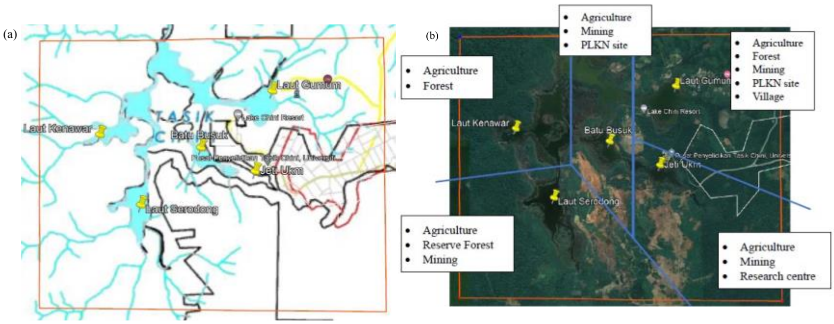

Figure 2.2 : (a) Water Catchment area in Tasik Chini (PLAN Malaysia, 2022) and (b) Sampling point and land use activity.

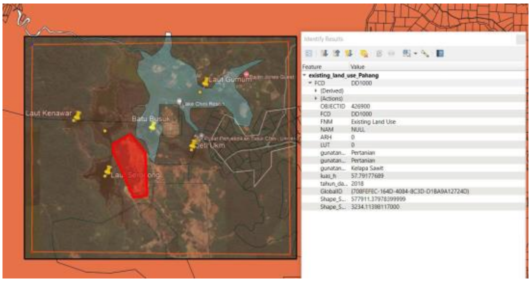

Figure 2.3 : Identification of land use in QGIS

3 Result and discussion

3.1 Landuse analysis using QGIS

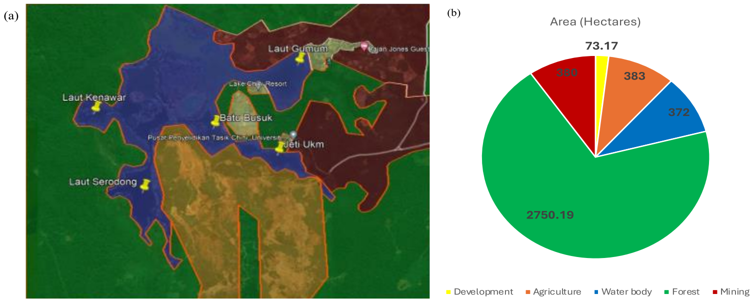

Figure 3.1 : (a) Land Use Activity Plot in QGIS and Google Earth; (b) Area of Land Use in Tasik Chini.

Figure 3.1(a-b) shows that the forest area dominated the land use at the Tasik Chini, acting as a natural water catchment area for the Tasik Chini, covering 2750.19 hectares or 69.48% of the total area. Then, the dominant land use in the Tasik Chini was agriculture (383 hectares). The mining area was the third largest, covering 380 hectares or 9.60% of the area. The water body itself spanned approximately 372 hectares, constituting the main part of the Tasik Chini. Lastly, 73.13 hectares was calculated to be the development, which is the smallest area in the Tasik Chini. The development area included residential zones such as Kampung Gumum, a research facility (the former National Services Training Program camp), and the Tasik Chini Resort. This analysis indicates that the agricultural and mining activities were significantly affect the water quality of the lake, as these areas were substantial sources of potential pollutants.

3.2 Water Quality Analysis

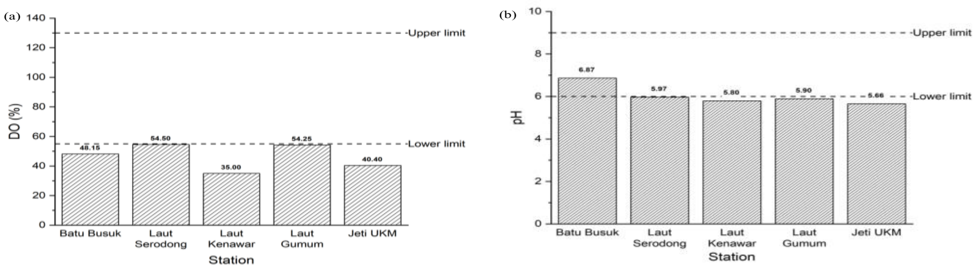

Figure 3.2 : (a) Measurement of DO (%) and (b) Measurement of pH at Tasik Chini.

Figure 3.2 (a-b) show the measurement of the DO and pH at Batu Busuk, Laut Serodong, Laut Kenawar, Laut Gumum dan Jeti UKM at the Tasik Chini. The highest DO values were recorded at Laut Serodong and Laut Gumum with 54.5% and 54.25% respectively. While the control point (Laut Kenawar) shows the lowest measurement of DO (35%), and followed by Jeti UKM (40.4%). The difference between the highest and lowest DO values was 36%, indicating that the DO in the Tasik Chini was not consistent was probably due to the landuse and stagnant water at certain locations. According to the NLWQS, Tasik Chini is categorized as Class C, Therefore, the DO percentage saturation should be between 55% to 130%. However, none of the sampling points at the Tasik Chini reached this minimum DO measurement, indicating that this lake required urgent mitigation to enhance the DO concentration in the lake. Previous study has reported that the DO concentration of the Tasik Chini was significantly decreased due to the severe sedimentation and wash away algae (oxygen-generating plants) during the severe flood in 2014 (Mohamed et al, 2024 and Gary, 2014). Other factors that may contribute to the decreasing of the DO concentration at the Laut Kenawar was probably due to the high consumption of fertilizer from the agriculture activity and condition of stagnant water that limited the natural aeration process. Figure 3.2 (b) shows the pH measurements at these sampling points were in the range of 5.66 to 6.87. Batu Busuk was recorded as the highest pH (6.87), while Jeti UKM was the lowest pH (5.66). According to the NLWQS for category C lakes, the pH should be in the range of pH 6.0 - 9.0. This result indicates that only Batu Busuk shows neutral pH, while other points show acidic condition (>pH6). Referring to Figure 3.1 (a-b), this lake is surrounded by the mining and agriculture area, indicating that contaminated runoff from this area may significantly altered the pH of the water. For example, chemical reactions like hydrolysis and oxidation can convert sulfide minerals into sulfuric acid at active and abandoned mine sites, leading to decrease the pH of water (Yaacob, 2009). Based on this finding, the Tasik Chini significantly required good management practices of lake to preserve the existence aquatic live and biodiversity.

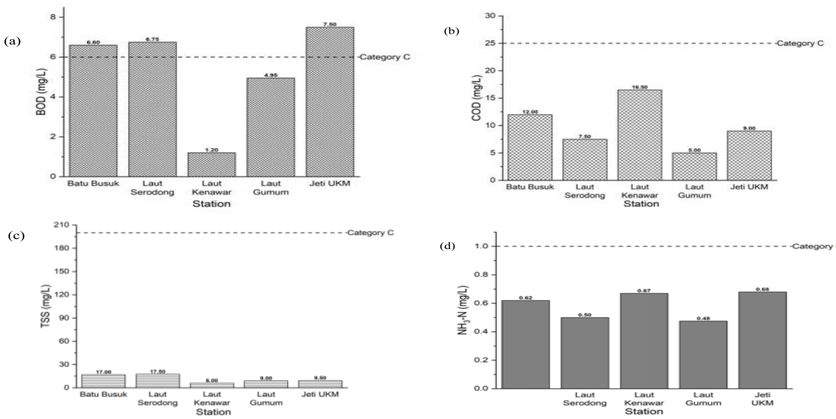

Figure 3.3 (a-d): Measurement of BOD, COD, TSS and NH_3-N at Tasik Chini.

Figure 3.3 (a-d) show result analysis of BOD, COD, TSS and NH_3-N at Batu Busuk, Laut Serodong, Laut Kenawar, Laut Gumum dan Jeti UKM at the Tasik Chini. Interestingly, all these parameters were within the range of category C of this lake except for BOD concentration. According to the NLWQS, the BOD limit for category C lakes is 6 mg/L, and only BOD concentration at the Laut Kenawar and Laut Gumum were in range of category C. Different concentrations of BOD at these sampling points, suggesting that the accumulation of sedimentation and pollutants from the agriculture and mining activities significantly affect the water quality of the lake (Khalik et al., 2022). The concentration of COD and NH_3-N also fluctuated at these sampling points, suggesting the influenced of pollutant from the nearby landuse that may significantly affect the water quality of the lake but still under the allowable limit of category C (COD<25mg/L and NH_3-N<1 mg/L). Concentration of TSS was in the range of 6 mg/L to17.50 mg/L, indicating the TSS concentration was significantly below the allowable limit of the TSS concentration of category C (TSS<200 mg/L). Therefore, suitable mitigation to control concentration of BOD is required for the Tasik Chini.

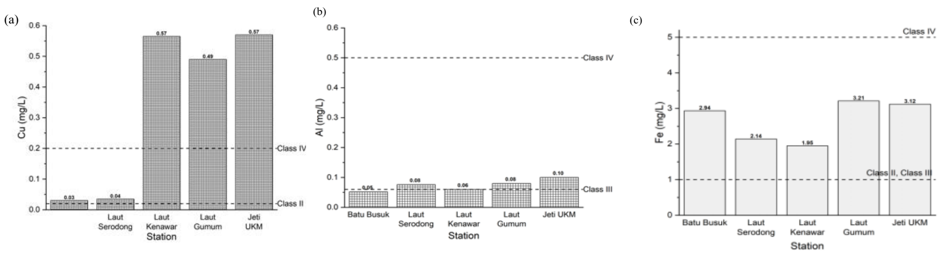

Figure 3.4 (a-c): Measurement of Cu, Al and Fe at Tasik Chini.

Figure 3.4 (a-c) shows the measurement of Cu, Al and Fe at Batu Busuk, Laut Serodong, Laut Kenawar, Laut Gumum dan Jeti UKM at the Tasik Chini. Figure 3.4a shows the highest Cu concentrations were found at the Laut Kenawar (0.57mg/L) and

Jeti UKM (0.57mg/L) and followed by Laut Gumum (0.49 mg). While the lowest concentration of Cu was identified at the Laut Serodong (0.04 mg/L) and Batu Busuk (0.03 mg/L). Source of Cu probably from the mining and agriculture activities. Figure 3.4b shows that the Jeti UKM shows the highest Al concentration (0.1 mg/L), followed by Laut Kenawar (0.06 mg/L), Laut Serodong (0.08 mg/L), Laut Gumum (0.08 mg/L) and Batu Busuk (0.05 mg/L). This result shows that the concentration of Al was almost consistent all sampling points, indicating that source of Al probably from the mining activity and it was transported into the lake through the movement of suspended solid. Figure 3.4c shows the concentration of Fe at the Laut Gumum recorded the highest Fe concentration (3.21 mg/L), then Jeti UKM (3.12 mg/L), Batu Busuk (2.94 mg/L), Laut Serodong (2.14 mg/L) and Laut Kenawar (1.95 mg/L). Literature have reported that source of Fe was from the mining area, and it significantly dissolved in the neutral and acidic water. Referring to Figure 3.1(b), pH of the lake is neutral and slightly acidic (pH 5.66 to 6.87). Therefore, concentration of Fe was approximately high at all sampling points. Mining area also located at the upstream of the lake and discharge of the Fe from the mining area may easily distributed to the downstream of the lake (e.g., Laut Kenawar, Laut Serodong and Batu Busuk). Referring to the NLWQS, concentration of Al and Fe were in the range of Class IV, except for the concentration of Cu was in the class V for all sampling points. Therefore, urgent mitigation measures are urgently reguired for the Tasik Chini. Table 3.1 shows the result of calculation of the sub-indexes and WQI at all sampling points at the Tasik Chini. The sub-indexes measured include pH level (SIpH), Suspended Solids (SISS), Dissolved Oxygen (SIDO), Ammonia Nitrogen (SIAN), Biochemical Oxygen Demand (SIBOD), and Chemical Oxygen Demand (SICOD). The WQI analysis shows that WQI of the Tasik Chini is dominantly under Class III (average). The WQI data was significantly affected by the low concentration of DO in the water (SIDO was in the range of 28 to 55). Therefore, critical mitigation measures are urgently required to improve the concentration of DO in this lake for long-term preservation of the Tasik Chini.

Table 3.1: Sub-indexes for Tasik Chini, Pekan, Pahang

Water Quality Parameter		Station				
		Batu Busuk	Laut Serodong	Laut Kenawar	Laut Gumum	Jeti UKM
Sub-Indexes	SI_{pH}	92.80	89.90	82.26	89.18	84.70
	SI_{SS}	87.91	87.60	93.97	92.28	91.98
	SI_{DO}	47.09	56.27	28.91	55.97	35.50
	SI_{AN}	72.81	78.09	71.15	79.30	70.33
	SI_{BOD}	74.47	74.14	95.33	80.50	70.83
	SI_{COD}	83.14	89.13	78.62	92.45	87.13
Water Quality Index		73.93	77.24	72.63	79.76	70.64
Class		III	II	III	II	III
Water Quality Status		Average	Good	Average	Good	Average

4 Conclusions

Tasik Chini is one of the largest freshwater lakes and rich with diverse aquatic species and biodiversity. The Tasik Chini is under Category C, where it is significantly for the preservation of aquatic life and biodiversity. This study is aimed to investigate water quality and landuse surrounding the Tasik Chini. QGIS was used to identify the current land use at the Tasik Chini. Interestingly, the lake was surrounded dominantly by the forest (69.48%), agriculture area (palm oil plant) (9.69%) and mining area (9.60%). Measurements of DO, pH, NH_3-N, COD, BOD, TSS, Fe, Cu and Al were conducted in this study. Water quality analysis shows that the WQI of the Tasik Chini was dominantly under Class (III). The concentration of Al and Fe were in the range of Class IV, except for the concentration of Cu was in the class V for all sampling points. The analysis of water quality shows that all parameters were in the range of category C, except for the DO, BOD and pH at the selected sampling points. However, the WQI analysis shows that concentration of DO is the most critical compared to other parameters and significantly decreased the value of WQI of this lake. The concentration of DO was significantly critical and the existence of Fe, Cu and Al (class IV) significantly deteriorated the water quality of the Tasik Chini. Therefore, suitable mitigation measures are required to control the chemical runoff from the mining and agriculture activities, enhanced vegetation cover along the lake, implement natural aeration system and enhanced water quality monitoring to preserve the natural ecosystem of the lake. The findings from this study could provide better environmental management to control landuse development and sustain the water quality of the Tasik Chini.

Acknowledgements

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