Status and Contamination Level of Water Quality in Lake Chini, Malaysia

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Abstract—The study investigates the spatial variation and index of water quality in Tasik Chini (Chini Lake), Pahang, Malaysia. Water sampling was conducted from 15 representative sites within the lake including five major feeder rivers. Major physico-chemical indicators of water quality were analyzed using standard procedures. Observed research data were calculated according to Department of Environment Water Quality Index (DOE-WQI) and classified in comparison with National Water Quality Standard, Malaysia (NWQS). pH and ammoniacal nitrogen were most polluted parameter in the study area. Station T4 was worse in condition (class III) where tributaries were mostly polluted followed by agriculture and mining area at station L3 and L4. The lake water quality was classified as class II based on WQI Malaysia. That is quite suitable for body contact and recreational purpose.

Keywords— Water pollution, Water resources, Lake Chini, Water Quality Index (WQI)

1. INTRODUCTION

Malaysia is going under massive economic development from last two decades. Land transformation, urbanization, industrialization and expansion of agriculture are accompanied by the development. Natural water courses are affected both in quantity and quality by these factors [1]. Current water quality status information is required to understand and solve this problem perfectly [2]. Demand for fresh water increasing day by day although sources are limited. Mass anthropogenic activities at the fresh water reserves modify the nutrient flux and change the physico-chemical properties [3]. Perfect monitoring and management of drinking water is crucial. But monitoring of physico-chemical and biological properties of water especially in drinking water supply is a routine assessment in Malaysia [4]. So protection of fresh water resources is important.

Malaysia has only two notable fresh water natural lake. Tasik Chini stands after Tasik Bera in accordance of size [5]. There are many artificial impounds in Malaysia including dams. These functions as electric power generation, irrigation, household and drinking water supply, aquaculture and tourism spot [6]. Tasik Chini was endorsed as the first Malaysian UNESCO biosphere reserve in 2009. This lake is 100 km away from the state capital Kuantan. The surface area of the lake is 6,922,97 ha and impound by undulating hilly areas [7].

This beautiful lake changes its nature and motion from last two decades. The ecosystem modifies semi lotic to lentic with concentrated nutrients due to the installation of a small dam at the draining point of the lake. The dam was launched by the local government ignoring experts, to raise the lake's water level. The main idea behind this was to income more revenue from fish production and tourism. But raised water level adversely affects increased sedimentation and nutrients [8]. On the other hand, shifting agriculture, illegal logging and rapid settlement in the catchment area impacts on the lake. Enormous mining operation is running spreading a large area on the upper area attaching to the shore. This exports excess sediment and toxic metals downward to the lake. Therefore, it is necessary to assess the current pattern of the lake water quality to understand the pollution and future management.

2. MATERIALS AND METHOD

A. Study Area

The gazetted Tasik Chini Park and the catchment are enclosed by three hills namely; Bt. Ketaya (209 m), Bt. Tebakang (210 m) and Bt. Chini (641 m). Some endemic habitats found only in Bt. Chini [7]. Annual rainfall occurs between 1,488 to 3,071 mm in this tropical hot and humid area. Twelve distinct reservoirs conforms together a finger like structure, locally called "Laut". The riparian areas and surrounding low lands are densely populated with indigenous dipterocarp forest [9]. Only two seasons occurs in the study area are, dry season and rainy season.

B. Sampling

Samples were collected from 15 selected spots during the rainy season in 2015. Where 10 stations are in the major reservoir of the lake and rest five were in the tributaries feeding into the lake. Properly cleaned HDPE 1L bottles were used to collect water samples from about 10-15 cm below of the surface for physico-chemical analysis [10]. On the other hand, 300 ml black BOD bottle were used to collect samples for BOD. All sampling bottles were immediately shifted inside the cooler box with ice and carried along the way to laboratory on same day. Finally, both kinds of samples were stored into the laboratory cold room in cool and dry condition below 4^{0}C for future analysis. The sampling sites in the study area were as follows:

Station L1	Mining zone and palm oil cultivation
Station L2	National service training camp, forest area, and logging zone
Station L3	Logging, mining and agriculture
Station L4	Mining and agriculture
Station L5	Forest area
Station L6	Forest area
Station L7	Draining end point of the lake at Chini River
Station L8	Village followed by agriculture
Station L9	Building infrastructure for tourist and forest.
Station L10	Agriculture and village area
Station T1	Tributary coming through agriculture and village
Station T2	Tributary coming through agriculture and village
Station T3	Tributary coming through mining zone
Station T4	Tributary coming through mining, agriculture and village
Station T5	Tributary coming through mining, agriculture and village

C. Physicochemical Analysis

Temperature, dissolve oxygen (DO), electrical conductivity (EC) and pH were determined among the physical parameters using YSI multiparameter in the field. Whereas, turbidity measured using turbidity meter; TSS and TDS determined using Hydrolab in the laboratory. Chemical indicators including nitrate (NO_3), ammoniacal nitrogen (NH_3-N), sulphate (SO_4), phosphate (PO_4) and chemical oxygen demand (COD) were analyzed performing spectrophotometer (HACH DR5000 model) [11]. All analysis was followed according to the recommendation and protocols of American Public Health Association APHA [12] and ISO [13]. BOD_5 of the sample was detected reading the difference between initial dissolve oxygen and 5th day incubated dissolve oxygen at 20 ^{0}C using DO meter. WQI was formulated combining DO, BOD, COD, ammoniacal nitrogen (AN), TSS and pH based on DOE-WQI as mentioned by [14] and [15]. The equation that calculates WQI is as follows:

$$WQI= 0.22 (SIDO) + 0.19 (SI BOD) + 0.16 (SI COD) + 015 (SIAN) + 0.16 (SI SS) + 0.12 (SI pH)$$

where SI refers to the sub-index function for each of the given parameters and the coefficients are the weighting factors derived from the opinion poll.

D. Statistical analysis

All individual water quality indicators were primarily computed with standard deviation and mean value [16]. Collected data were analyzed and simplified using Microsoft Office Excel 2010 and Statistical Package for Social Scientists (IBM SPSS Statistics) 21th version. For understanding the significance among the sampling stations two-way ANOVA was carried out [17]; [18]. All data were normalized performing Kolmogorov-Smirnov test (K-S test). Two-tailed Pearson correlation analysis was carried out to reveal the significant relationship among the indicators [19].

3. Results And Discussion

Statistical analysis (Two-way ANOVA) calculates significant differences (P<0.01 is truly significant and P<0.05 is possibly significant) among the sampling stations. The results compared with national standard showed the water quality of Tasik Chini is class II. DOE-WQI calculates the mean water quality of 81.48±8.28, which ranges between 61.52 (class II) - 88.44 (class III) (Fig. 2). This quality of water allows body contacts and recreational activities [15]. National water quality standards (NWQS) compares the water quality indicator mean values into different categories individually as; temperature within normal range, EC, TDS, TSS, nitrite and sulphate are categorized under class I. Parameters included as class II are DO, BOD_5, COD and turbidity; pH and AN were classified as class III accordingly. No phosphate standard was stated in the NWQS comparator. This study results reveals similar with a research conducted in Tasik Bera (largest natural fresh water lake and 50 km away from Tasik Chini), where [20] found temperature ranged between 23.7-31.2 ºC, DO 1.36-4.00 mg/L, EC 10.5-23.0 µS/cm, sulphate 0.69-5.59 mg/L, phosphate 0.00-0.105 mg/L, nitrate 0.01-0.29 mg/L and AN 0.00-0.767 mg/L.

Four tributaries among five (except station T1) stations showed significantly lower water temperature (25.23±0.42 to 26.37±0.24 ºC) due to flowing through the cooler region of the catchment. But other stations at different reservoirs detected steady temperature (29.90±0.15-31.38±0.16 ºC). EC and TDS occurred higher around the area where human interaction is more frequent with strong positive correlation (r=0.992, P<0.01). Station T4 at Melai river detected maximum contaminated (EC= 166.45±2.63 µg/cm and TDS= 100.20±3.40 mg/L) followed by station T5 and L3, where human habitation and agriculture is present (Fig. 1).

Most of the stations at tributaries were acidic due to lack of DO and on the reservoirs DO were low near the villages. DO was negatively correlated with BOD (r= -0.809, P<0.01) and major nutrients. This decrease in DO was caused by the presence of organic matter. Turbidity was recorded maximum at the station T5 (57.19±3.32 NTU) followed by station L8 and L3 (Figure 1). Meanwhile TSS was also higher at Melai catchment and Cenahan catchment. Turbidity and TSS were found correlated (r=0.30, P<0.05) together.

Simultaneously higher BOD and COD across the tributaries (except station T1) indicate the increased consumption of DO, while DO trend was negative at this area. BOD and COD were strongly correlated (r=0.964, P<0.01) between them and both with sulphate (r=0.862, P<0.01; r=0.827, P<0.01) and AN (r=0.77, P<0.01; r=0.825, P<0.01). This means that accumulation of excess nutrients from agriculture and settlement sanitary stipulating the bloom of microorganism. Sulphate was detected maximum at the tributary T4 (3.01±0.17 mg/L) and minimum at the reservoir station L9 (0.02±0.005 mg/L). Phosphate was detected maximum at the Gumum catchment, station T2 (0.19±0.04 mg/L) occupied by village and varied agriculture and minimum was at the forest area station L5 (0.04±0.02 mg/L).

DOE-WQI classified the stations pollution status into three categories of water quality; clean (WQI=81-100), slightly polluted (WQI=61-80) and polluted (WQI=<60). Station T2, T4 and T5 were categorized under class III and rest all were under class II of water quality. The Figure 2 illustrates that, all the tributaries (except station T1) and Melai catchment reservoir are slightly polluted and all others are clean. From the above analysis it is identified that Melai catchment, Gumum catchment and Cenahan catchment are polluted mainly by anthropogenic activities, agriculture, illegal logging and unhygienic defecates. While mining and illegal logging at Jemberau catchment pollutes the tributary along with reservoir.

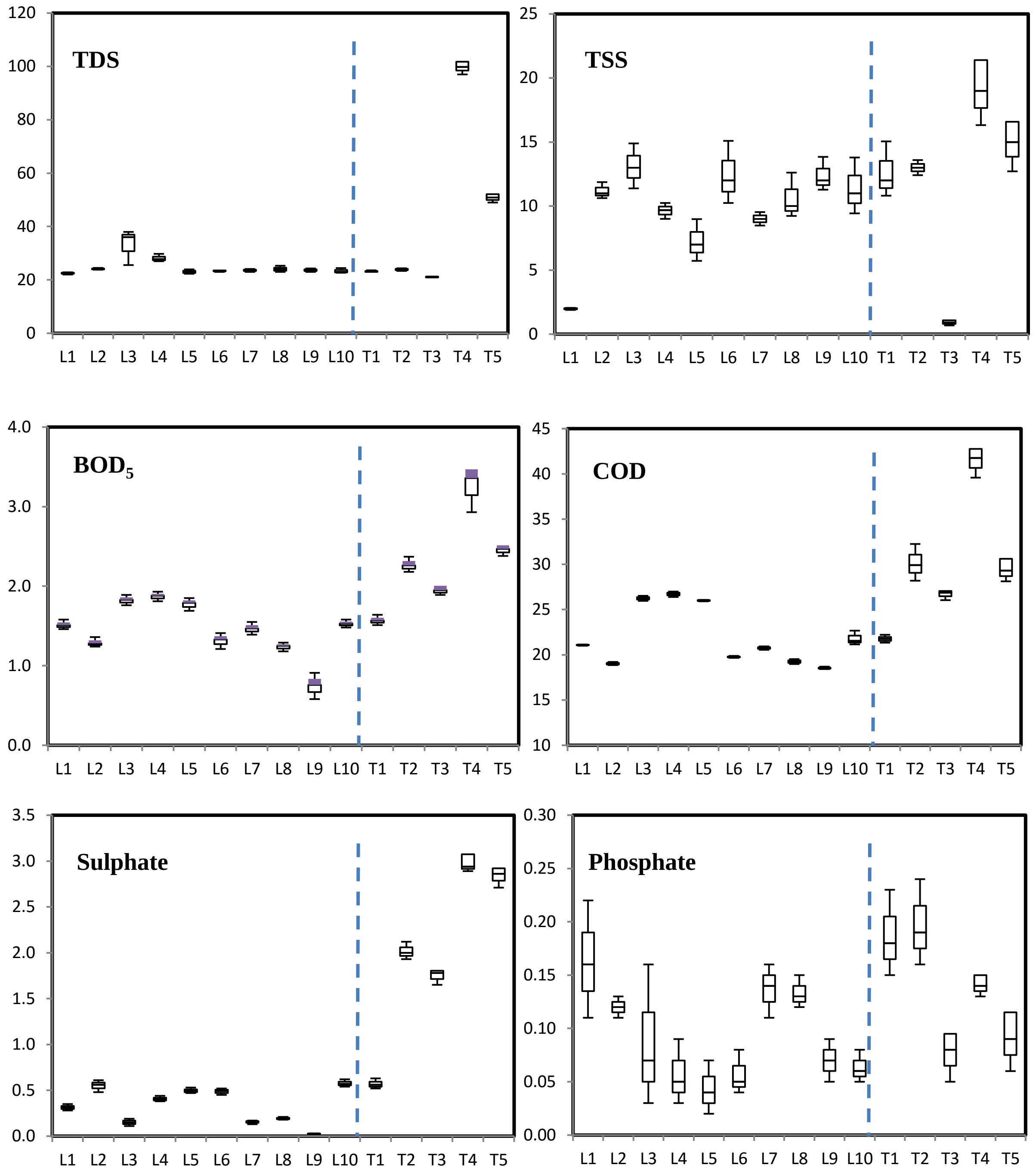

Figure 1: Physico-chemical distributon over the sampling stations at Tasik Chini.

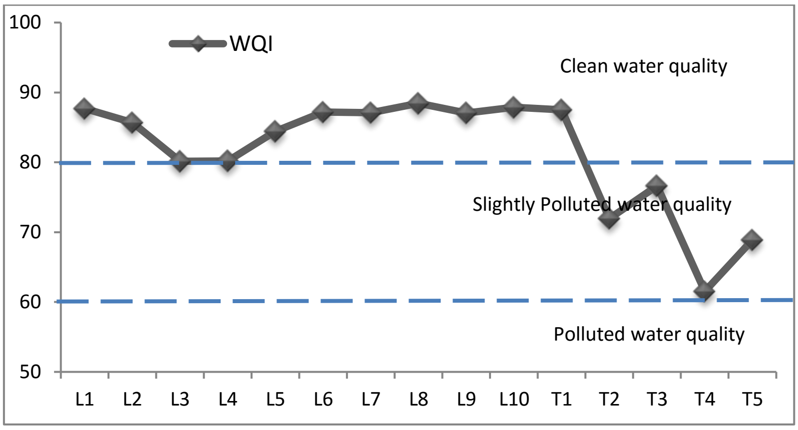

Figure 2: Pollution status of the lake water according to DOE-WQI

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