Water Quality Status and Heavy Metal Contains in Selected Rivers at Tasik Chini due to Increasing Land Use Activities

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Abstract. This study investigates the current water quality levels in the rivers around Lake Chini namely Jemberau River and Chini River during the dry season of 2018 and the rainy season of 2019. There are thirteen types of water quality parameters and seven types of heavy metals have been made experimental and classified based on the Water Quality Index which is from the Department of Environment (DOE-WQI) and the National Water Quality Interim Standard, Malaysia (INWQS). There are chemical and physical parameters that have been analyzed such as pH, temperature, turbidity, Electrical Conductivity (EC), Suspended Solids (SS), Total Suspended Solids (TSS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonia Nitrogen (NH3-N), Potassium (K), Nitrate (N) and Phosphorus (P) were analyzed at the sample site and laboratory experiments were also performed. In addition, there are seven types of heavy metals that have been tested in the laboratory to determine the concentration of heavy metals contained in the water samples from the Chini River and the Jemberau River which are Copper (Cu), Chromium (Cr) Cadmium (Cd), Ferrum (Fe), Zinc (Zn), Manganese (Mn) and Lead (Pb) were tested using laboratory tools named as Atomic Absorption Spectroscopy (AAS). Based on the results of the study conducted according to the Water Quality Index (WQI), the water quality at selected locations which are Jemberau River and Chini River located near Lake Chini was classified as Class III which means water in the river requires extensive treatment to ensure water quality return clean and safe to use as drinking water to the locals in the future. According to the results of the study, there are activities conducted around Lake Chini which have caused water pollution which involves the release of heavy metals. Among the activities identified as the main cause of water pollution in Lake Chini are iron mining, agriculture, illegal logging and waste disposal from residential areas such as the National Service Training Program (PLKN).

1. Introduction

Water is very important to human daily life in order to do their daily routine especially for drinking. Lakes are one of major water source in Malaysia as freshwater because they are often fed by rivers, rain and springs. The lake is very sensitive area because there are potential exposure pollutants from many sources. For example, pollution can flow through the water body of the lake from runoff and from the deposition of atmospheric. The limited water movement within the lake affects the level pollution in the lake environment. Moreover, high concentrations pollutants can reduce the biodiversity of the lake ecosystem and change the physical environment around the lake. In Malaysia, Tasik Chini which is located within the state of Pahang on the east coast of Peninsular Malaysia is the second largest natural lake in Malaysia after Tasik Bera. Surface area of the Tasik Chini covers 12,565 acres and it was surrounded by natural forest and aboriginal settlements. Tasik Chini has a unique shape that consists of 12 small lakes that local people called as "Laut" which is interconnected by natural channels. Tasik Chini has recreational value and ecological importance in terms of its

biodiversity as this area richly endowed with biological resources and some 288 species of plants, 21 species of aquatic plants, 92 species of birds, and 144 species of freshwater fish.

Tasik Chini is an ecological area which is importance due to large biodiversity and it is also very important for local parties' economy. The mainstay economy is mainly forest-based and agriculture-based activities [1].These activities could be the source for pollution to the lake. There are logging, iron ore mining, rubber plantation, palm oil plantation and residential area. There is presence of heavy metals that come from iron ore mining activities which gives bad effect to water quality of Tasik Chini. Accumulation of metals and organic pollutants in the sediments may have long-term adverse effects on aquatic organisms [2]. Heavy metals concentration such as Lead (Pb), Iron (Fe), Manganese (Mn), Cadmium (Cd), Zinc (Zn) and Chromium (Cr) become increasing due mining activities. Heavy metals are a metallic element that has a relatively high density, specific gravity, or atomic weight and has toxic effects [3]. Meaning that, if there are unwell-operated for mining activity, it will causes increasing of heavy metal concentrations in water body because lake is a stagnant water area surrounding by land which is term water pollution refers to any types of aquatic pollution between two extremes of a highly productive body of water poisoned by toxic chemicals that eliminates living organisms. Water quality is among the most important environmental issues related to sustainable development, especially to ensure national drinking water safety [4].

The water quality pollutants, such as organic pollutants (permanganate index), nutrients (total phosphorus), total suspended solid, and chlorophyll-a were significantly influenced by the proportion of forest and grass land and the consumption of phosphate fertilizers in tributaries [5]. Water quality can be defined as the chemical, physical, biological, and radiological characteristics of water. This is a measure of water conditions over the requirements of one or more biotic species and or to any human purpose. This is most often used with reference to a set of standards for which compliance, generally achieved through water treatment that can be assessed. The most commonly used standards for assessing water quality are ecosystem health, human safety, and drinking water. The water quality parameters for the lake, measured according to Malaysia Department of Environment Water Quality Index (DOE-WQI) also, will classified by using National Water Quality Standard, Malaysia (NWQS).

1.1 Research Objectives
i) To evaluate the characteristics of each water quality parameters and to analyze the current status of water quality at Jemberau River and Chini River during rainy season in 2018 and dry season in 2019.
ii) To identify current heavy metals level in Jemberau River and Chini River.

1.2 Scope of Study
This research is conducted on October 2018 until February 2019. The location of study area is at Tasik Chini, Pahang. The scope of study in this research is about effect from land use activities to the water quality at Jemberau River and Chini River that are currently facing problem due to mining activity, logging activity and agricultural activity. All of this activity can contribute to the increasing of heavy metal concentration in the river and will give worse effect to the water quality at Tasik Chini. The increase in water demands causes more conflict between the human system and the river ecological system[6]. Figure 1 show the view of Jemberau River. The coordinate for this station is $03^o41.952''$ North and $102^o93.121''$ East as shown in Figure 2. Figure 3 show the view of Chini River. The coordinate for this station is $03^o45.091''$North and $102^o89.194''$ East in Kuantan, Pahang as shown in Figure 4.

Figure 1. Jemberau River, Tasik Chini

Figure 2. Coordinate for Jemberau River

Figure 3. Chini River, Tasik Chini

Figure 4. Coordinate for Chini River

2. Study Area

The lake is serves to refill underground water, affect the water quality of the groundwater catchment, and maintain the biodiversity and habitat of the area. Dam, reservoirs and lakes are important in the conservation of basic national resource-water [7]. The two largest freshwater lakes in Malaysia which are Tasik Chini and Tasik Bera are located on the same river basin known as Pahang River Basin.

Tasik Chini is the study area for this research. Tasik Chini is the second largest natural lake in Peninsular Malaysia which is located at Pahang. This lake plays vital role as a natural wetland ecosystem due to its presences that can decrease the velocity, frequency and level of floods and riverbank erosion. This lake is important for local people for providing the fish source and basic facility for transportation such as boating. Since Tasik Chini flows to the main river which is Pahang River, it is influence by the intertidal monsoon season.

In recent years, specific concerns about the impacts of climate change on water eutrophication, which causes global environmental challenges regarding the management of water resources, have been raised [8].Due to uncontrolled flowing-in of pollutants such as organics, nitrogen, phosphorus, receiving water bodies often experience algal blooming, floating, and deterioration of biodiversity, eventually negatively-affecting human life [9]. The worse effect from these changes were damages to the plant community, aquatic ecosystem and raise the sedimentations level in the lake.

3. Methodology

Water quality parameters for lake, are measured in accordance to Malaysia Department of Environment Water Quality Index (DOE-WQI) also, will categorized by using skill of the use of National Water Quality Standard, Malaysia (INWQS) [10].

Water samples are taken twice during the rainy season and dry season. Water samples for the rainy season were taken on October 2018, while samples for dry season were taken on February 2019. At each station, three bottles of 500 ml for water sample was collected at 10 cm below the surface area. There are two types of test carried out which are in-situ tests and laboratory tests. For in-situ tests, five parameters are measure such as temperature, pH, turbidity, electrical conductivity (EC), and Dissolved Oxygen (DO). While for laboratory test, 10 tests were conducted on Biological Oxygen Demand (BOD) test, Chemical Oxygen Demand (COD) test, Total Suspended Solid (TSS) test, Suspended Solid (SS), Nitrate test, Ammoniacal Nitrogen test, Phosphorus test, Potassium test, Hardness test and Heavy Metal test. Water samples are collected at 10cm below the surface water using HDPE bottles. The sample should be kept in the ice box at temperature 4ºC and transported to the laboratory for analysis. The preservation technique of water sample was different based on the tests that to be carried out. The preservation techniques are shown in the Table 1 below:

Table 1. Preservation Techniques

Parameter	Container	Preservation	Maximum Holding Time
Inorganic Tests			
Ammoniacal Nitrogen	P,G	Cool, 4ºC H_2SO_4 to pH <2	28 days
Biochemical oxygen demand		Cool, 4ºC	48 hours
Chemical oxygen demand	P,G	Cool, 4ºC H_2SO_4 to pH <2	28 days
Hardness	P,G	HNO_3 to pH <2	6 months
Nitrate	P,G	Cool, 4ºC	48 hours
Phosphate	G	Cool, 4ºC	48 hours
Residue, non- filterable (TSS)	P,G	Cool, 4ºC	28 days

Adopted from Environmental Protection Agency Guidelines for handling and preserving samples, P=plastic, G= glass

4. Results and Discussions

Table 2 shows in-situ and laboratory test results for sample collected at Jemberau River during rainy season in 2018 while Table 3 shows the results for dry season in 2019.

Table 2. Data collection and laboratory test for Jemberau River during rainy season 2018

PARAMETER	UNIT	SAMPLE VALUE
Temperature	°C	25.10
DO	mg/L	5.36
pH	-	5.08
EC	μS/cm	32.40
Turbidity	NTU	7.06
BOD	mg/L	0.20
COD	mg/L	29.00
NH3-N	mg/L	0.05
TSS	mg/L	3.00

Table 3. Data collection and laboratory test for Jemberau River during dry season 2019

PARAMETER	UNIT	SAMPLE VALUE
Temperature	°C	27.30
DO	mg/L	4.38
pH	-	5.76
EC	μS/cm	34.10
Turbidity	NTU	4.88
BOD	mg/L	8.06
COD	mg/L	30.50
NH3-N	mg/L	0.11
TSS	mg/L	17.00

Table 4 shows in-situ and laboratory test results for sample collected at Chini River during rainy season in 2018 while Table 5 shows the results for dry season in 2019.

Table 4. Data collection and laboratory test for Chini River during rainy season 2018

PARAMETER	UNIT	SAMPLE VALUE
Temperature	°C	28.60
DO	mg/L	2.49
pH	-	5.64
EC	µS/cm	35.60
Turbidity	NTU	45.60
BOD	mg/L	1.25
COD	mg/L	18.50
NH3-N	mg/L	0.10
TSS	mg/L	36.00

Table 5. Data collection and laboratory test for Chini River during dry season 2019

PARAMETER	UNIT	SAMPLE VALUE
Temperature	°C	27.30
DO	mg/L	1.82
pH	-	6.32
EC	µS/cm	31.30
Turbidity	NTU	17.70
BOD	mg/L	7.30
COD	mg/L	13.00
NH3-N	mg/L	0.50
TSS	mg/L	66.00

There are six parameters that are selected for WQI which are Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solid (SS). Ammoniacal

Nitrogen (AN) and pH. In addition, the calculations are not done on their own parameters but on their sub-index which are known as SIDO, SIBOD, SICOD, SIAN, SISS and SIpH.
The formula used to calculate the Water Quality Index is shown below:

$$WQI=(0.22*SIDO)+(0.19*SIBOD)+(0.16*SICOD)+(0.15*SIAN)+(0.16*SISS)+(0.12*SipH) \quad (Eq.\ 1)$$

where;
|		
SIDO	=	SubIndex DO (%saturtlon)
SIBOD	=	SubIndex BOD
SICOD	=	SubIndex COD
SIAN	=	SubIndex NH3-N
SISS	=	SubIndex SS
SipH	=	SubIndex pH

$0 \le WQI \le 100$
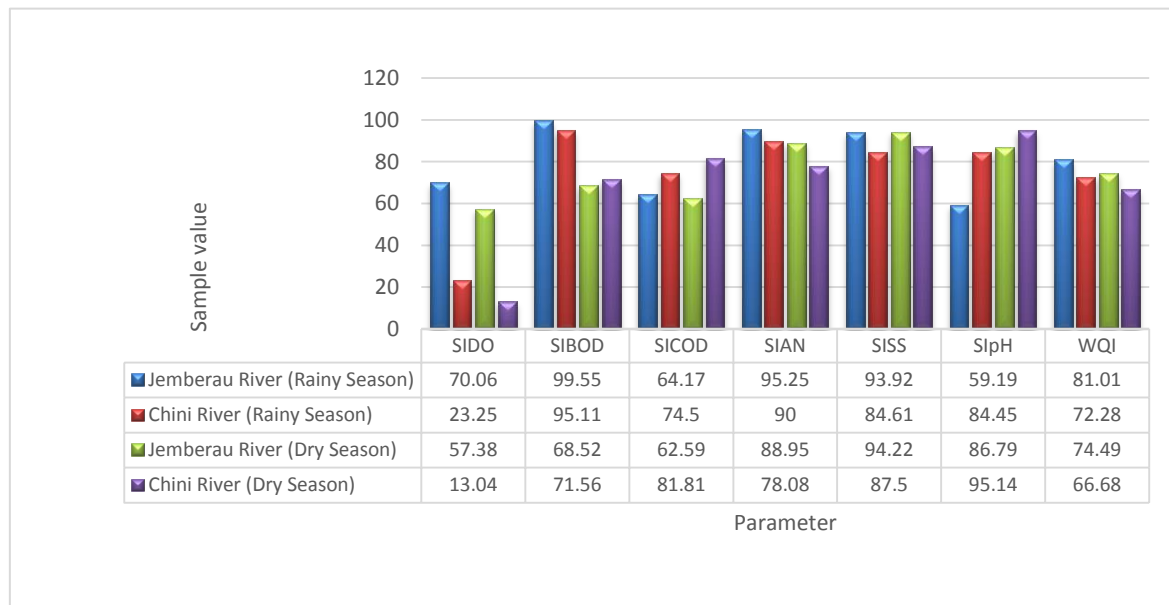
Figure 1. Water Quality Index at Jemberau River and Chini River during rainy season in 2018 and dry season in 2019

Figure 1 shows the Water Quality Index (WQI) for Jemberau River and Chini River. Based on DOE-WQI, the selected station at Jemberau River during rainy season in 2018 is classified in Class II, while Jemberau River during dry season in 2019 and Chini River during both rainy and dry season are classified in Class III. From above data, it is means that the water quality of Jemberau River and Chini River is different from the location of the sampling station.
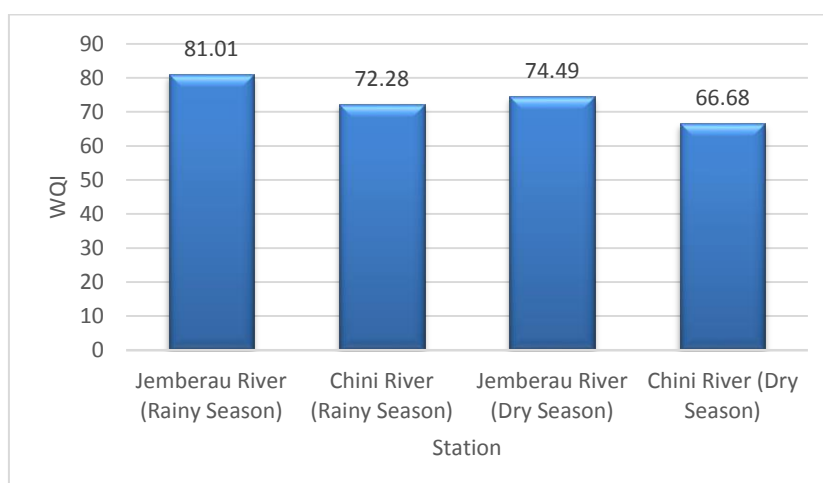
Figure 2. Water Quality Standard based on WQI at Jemberau River and Chini River during rainy season in 2018 and dry season in 2019

From Figure 2, it is shows that the water quality for all sampling stations at TasikChini during rainy season and dry season. According to DOE-WQI, station at Jemberau River during rainy season in 2018 is classified in Class II because the WQI value is 81.01 which is in the range 76.50-92.70, so that the water quality at this station is consider clean. While the other stations at Jemberau River during dry season in 2019 and Chini River during both rainy and dry season are classified in Class III. It is classified in Class III because of the WQI value for those rivers are in the range 51.90-76.50 which is the index range is classified as slightly polluted. The water pollution might be coming from the land use activities surrounding rivers such as mining activity, residential area and agricultural activity which generated by local people.

Table 6. Result of heavy metals using AAS method

Jemberau River	Chromium, Cr (mg/L)	Lead, Pb (mg/L)	Copper, Cu (mg/L)	Cadmium, Cd (mg/L)	Iron, Fe (mg/L)	Zinc, Zn (mg/L)	Manganese, Mn (mg/L)
October	-0.080	0.013	0.032	-0.021	0.492	0.005	0.069
February	-0.139	0.304	-0.031	0.454	-	-	-
Chini River	Chromium, Cr (mg/L)	Lead, Pb (mg/L)	Copper, Cu (mg/L)	Cadmium, Cd (mg/L)	Iron, Fe (mg/L)	Zinc, Zn (mg/L)	Manganese, Mn (mg/L)
October	-0.087	0.004	0.035	-0.023	1.57	0.00	0.080
February	-0.131	0.211	-0.036	0.454	-	-	-

Table 6 shows the concentration in unit mg/L for seven parameters of heavy metals in sample obtained at Jemberau River and Chini River during rainy season and dry season. These heavy metal levels are determined by Atomic Absorption Spectroscopy (AAS) which are seven parameters carried out in laboratory by using AAS method are Chromium (Cr), Lead (Pb), Copper (Cu), Manganese (Mn), Iron (Fe), Cadmium (Cd) and Zinc (Zn). Based on the data tabulated above, the concentration of heavy metals in water samples is slightly higher according to permissible range of NWQS. This situation occurs because of land use activities surrounding the rivers such as agricultural, mining and also emission of waste from residential area. All of this activity can lead to increasing water pollution at Jemberau River and Chini River.

5. Conclusions

Based on the analysis that has been made, station at Jemberau River and Chini River are classified as Class III which is according to index range of WQI, the station at Jemberau River and Chini River was classified as slightly polluted. In addition, the water sample collected from station Jemberau River is classified in Class III due to land use activity nearby the river such as mining activity that can cause surface runoff and contributes to heavy metals pollution. While, Chini River is also classified in Class III which is slightly polluted because there have the National Service Training Programme near the river and the effluent discharge from that activity flowing into the Chini River and cause the water pollution. In addition, Chini River also act as outlet to Pahang River, so that it will give worse effect in the future if the river is not treating well from now. Based on the collected data for two different stations of water samples that has been analyzed, we can conclude that the main sources of water pollution are comes from nearby mining activity. From the in-situ analysis and laboratory experiment, there are varied reading of parameter concentration based on different location and seasons. Other than that, the land use activity at certain location give the most impact to the reading taken especially for heavy metals concentration. According to NWQS and DOE-WQI, since the rivers are classified as Class III, hence the water supply need an extensive treatment and it is not suitable for drinking uses.

6. References

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