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Determination of Presence Iron and Manganese in Tasik Chini

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Abstract. This study investigates the current concentration of heavy metal in Tasik Chini which is iron and manganese. Status of water quality index (WQI) in the rivers at Tasik Chini namely Melai River, Jemberau River, Jerangking River and Gumum River was identified. The water quality results were classified based on the National Water Quality Standard, Malaysia (NWQS). Physical and chemical parameters 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), Phosphorus (P) were analysed on site and by laboratory experiments. Two types of heavy metals have been tested to determine the concentration of Iron (Fe) and Manganese (Mn) contained in the water samples in Melai River, Jemberau River, Jeranking River and Gumum River using laboratory tools named as Atomic Absorption Spectroscopy (AAS) and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). This (ICP-MS) method is conducting by Central Laboratory in Universiti Malaysia Pahang. Based on the results of the study conducted according to the Water Quality Index (WQI) and National Water Quality Standard, Malaysia (NWQS), the water quality at selected locations which are Melai River, Jemberau River, Jerangking River and Gumum River at Tasik Chini was classified in Class II where conventional treatment are required. According to the results of the study, there are activities conducted around Tasik 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 Tasik Chini are iron mining, agriculture, illegal logging and waste disposal.

Keywords: heavy metal, land use, pollution, Tasik Chini, water quality

1. Introduction

Water are important because it is needed for life. Besides, water have been used for a long time for agricultural, industrial, household, recreational and environmental activities. Malaysia have a lot of water resources and because of that, the demand for water has increased steadily in every year because of the increasing of the population of the living things. Malaysia receives a lot of rainfall averaging 3000 mm annually and the main water resources is derived from the groundwater and surface water. The demand for water in Malaysia has increased every year from 8.9 billion m³ in 1980 to 15.5 billion m³ in 2000 for agricultural, industrial and domestic purposes [1]. Besides, water resources management and availability of water must in good condition because it will directly related to the control or elimination of disease. The convenience of water available at home improves the quality of life [2]. Malaysia is a developing country where is the construction and development are everywhere especially in the area that has a lot of population. Malaysia also has another water resource which is from the lake. Lake is the area fill with water surrounded by land connected by the river or streams. Malaysia has a lot of lake such as Tasik Chini, Tasik Kenyir and Tasik Temenggor. The natural



process of eutrophication can give effect to the water quality in the lake. Besides, human activities like agriculture and development will accelerate the eutrophication process. In this case, the study is to determine the class of the water body at Tasik Chini which is at Melai River, Jemberau River, Jerangking River and Gumum River due to the effect of land use activities such as mining activities to settlements in the lake perimeter and plantation activity. Tasik Chini is the second largest natural lake in Peninsular Malaysia which is located at Pekan Pahang [3]. 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 [4]. Besides, Surface water is water found on the earth's surface. The most important factor in aspect of hydrological is for maintaining the stability of the lake ecosystem [5]. Next, In aspect of hydrological also, the connectivity of surface water are the concept referring to the movement of surface water flow from one region of the landscape to another [6]. Water pollution may harmful to human, animals and also water quality. Besides, it also will reduce the ecological value of the lake and when this occur, it will affect the other activities around the lake like recreational activity. The composition of the original soil in Tasik Chini are in the form of Barium (Ba), Manganese (Mn), Iron (Fe), Zinc (Zn), Copper (Cu) and Lead (Pb) [7]. Besides, high exposure to manganese has been associated with toxicity to the nervous system, producing a syndrome that resembles Parkinsonism including weakness, anorexia, muscle pain, apathy, slow speech, monotonous tone of voice, emotionless "masklike" facial expression and slow, clumsy movement of the limbs. In general, these effects are irreversible [8]. Other than that, although low iron intake or bioavailability are responsible for most anaemia in industrialized countries, they account for only about half of the anaemia in developing countries, where infectious and inflammatory diseases especially malaria, blood loss from parasitic infections, and other nutrient deficiencies are also important causes [9]. The water quality at Tasik Chini has been polluted after the iron mine that located nearly with Tasik Chini was re-activated again in 2005 because of high demand for iron. The water in the lake become murky caused by unregulated agriculture, mining and logging in the surrounding areas. This shown that, the increasing of the land use at Tasik Chini for mining and logging activity will cause water quality to be polluted. Besides, the increasing velocity of the river flow also can affect the increment of heavy metals concentration during rainy season. Heavy metals showed an increase in dissolved phase as the velocity increased due to their desorption from the suspended particulate matters [10]. The biggest impact from the mining activity that can be see clearly is the increasing of the heavy metal concentration such as iron (Fe), manganese (Mn), aluminium (Al), barium (Ba), and magnesium (Mg) in water body [11].

1.1 Research Objectives

There are three objectives in this research which is to determine the concentration of heavy metal in Tasik Chini which is Iron and Manganese. The second objective is to identify status of water quality index (WQI) at Tasik Chini for year 2020 and the last objective is to evaluate the characteristics of each water quality parameters.

1.2 Scope of Study

The purpose of this study is to determine heavy metal contain which is iron (Fe) and manganese at Tasik chini due to increasing of land use and water quality pollution cause from mining and logging activities. Mining work use acid mine because it can release heavy metal from ores. Besides, metal are soluble in an acid solution. This research is conducted on September 2019 until June 2020. The selected river is Jemberau River and Chini River because at this area are currently facing with the problem due to effect of erosion and sedimentation due to mining near the river. This mining activity will increasing the heavy metal concentration in the river and affect the environment, aquatic life in the lake and water quality at Tasik Chini. There are two type of test that will use to carry out to achieve the objective which is the in-situ test and laboratory test. For in-situ test, five parameters will be measure which is dissolved oxygen (DO), temperature, electrical conductivity (EC), turbidity and pH. Seven test will conduct for the laboratory test, which is, Total Suspended Solid (TSS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen test (AN), Nitrate test, Phosphorus test, and Heavy Metal test.

2. Study Area

Figure 1 to Figure 4 shows the view of every station which is Station 1 is Melai River, Station 2 is Jemberau River, Station 3 are Jerangking River and Station 4 are Gumum River. The view of all stations had been taken around Tasik Chini. By using a boat, the process of taking water sample at Tasik Chini become easier.



Figure 1. Melai River



Figure 2. Jemberau River



Figure 3. Jerangking River



Figure 4. Gumum River

The lake 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 [12]. 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 [13]. The pollution incidents due to instantaneously spilled pollutant from point source usually caused by industrial waste or transportation accidents occurring [14]. 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 [15]. The worse effect from these changes were damages to the plant community, aquatic ecosystem and raise the sedimentations level in the lake. Table 1 shows the location for selected station for this research. Melai River is located near agriculture activity. For Jemberau River, it located in the middle of Chini Lake. Jerangking River is located near logging activities at the upstream and the Gumum River is located near Orang Asli village, nearby the downstream.

Table 1. Name of stations

| District | Station | Coordinate | |
|-----------|------------------|--------------|----------------|
| | Location | Latitude | Longitude |
| Station 1 | Melai River | N 3°24'53.6" | E 102°54'36.0" |
| Station 2 | Jemberau River | N 3°25'18.8" | E 102°55'40.2" |
| Station 3 | Jerangking River | N 3°26'34.2" | E 102°54'49.7" |
| Station 4 | Gumum River | N 3°26'11.6" | E 102°55'43.8" |

3. Methodology

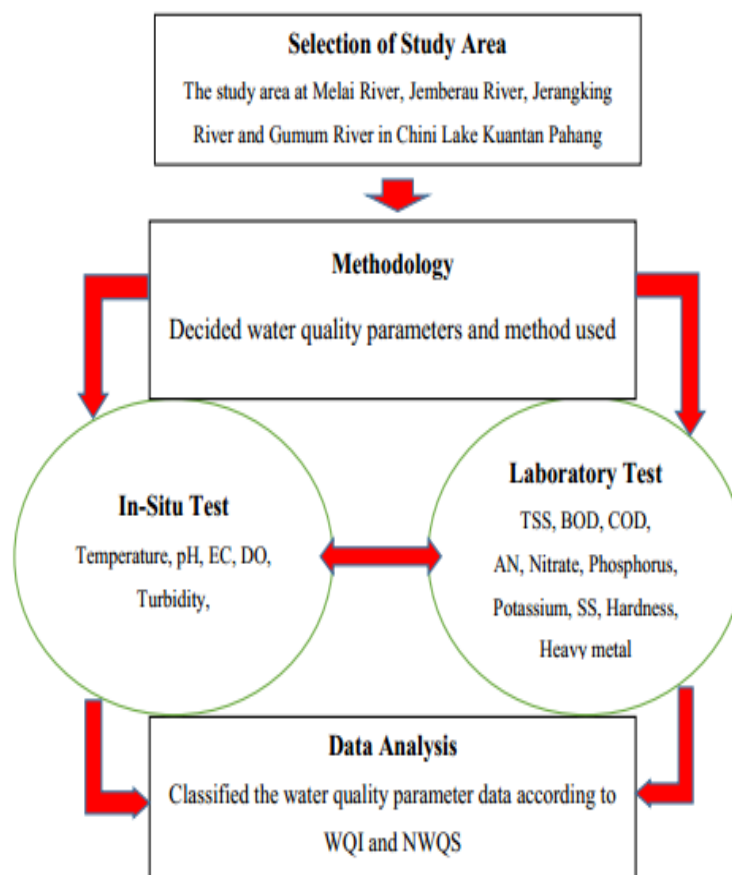
**Figure 5.** Flow chart of methodology

Figure 5 show the flow of methodology that was conduct during research. Four station which are Melai River, Jemberau River, Jerangking River and Gumum River. The water sample taken during dry season on February. The data for wet season had been taken from the previous study which is during 2017. At a station, three bottles water sample was collected at 10 cm below the surface area. There are two types of test that were conducted, in-situ test and laboratory test. For in-situ test, five parameters were measure which are temperature, pH, turbidity, electrical conductivity (EC), and Dissolved Oxygen (DO). For laboratory test, 8 test being conducted are 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, and Heavy Metal test. After all the parameter

were tested, the data will be analysed and classified based on WQI and NWQS. From the result and discussion, the water quality at Tasik Chini will be determined.

The formula used to calculate the Water Quality Index is shown below:

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

Where:

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

$$0 \leq WQI \leq 100$$

For heavy metals, two method that have been use in this research which is using Atomic Absorption Spectroscopy (AAS) which is used for a few targeted heavy metal which are Iron (Fe) and Manganese (Mn). For getting more accurate and faster result, second method had been used by using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) which is conducting by Central Laboratory in University Malaysia Pahang. Table 2 show that every stations for this research which is Melai River (MR), Jemberau River (JR), Jerangking River (JkR), Gumum River (GM) and Chini River (CR) and the date of the water sample had been taken which is during dry and wet season between 2020 and 2017

Table 2. Location of every station and the date

| Location | Date |
|------------------------|--|
| Melai River (MR) | February 2020 (Dry season) November 2017 (Wet Season) |
| Jemberau River (JR) | February 2020 (Dry season) November 2017 (Wet Season) |
| Jerangking River (JkR) | February 2020 (Dry season) November 2017 (Wet Season) |
| Gumum River (GR) | February 2020 (Dry season) November 2017 (Wet Season) |
| Chini River | November 2017 (Wet Season) |

The comparison between AAS method and ICP-MS method in aspect of analysis is, AAS use single element analysis while ICP-MS use multi elements analysis where ICP-MS will get faster result compare to AAS method. AAS method need to prepare 3-5 points for calibration for each element while ICP-MS method need to prepare 3-5 points for calibration for all the required elements. Next, AAS method are require long time for standards preparation while ICP-MS require short time for standards preparation.

4. Results and Discussion

From Figure 6, it is shows that the water quality for all sampling stations at Tasik Chini during dry season and wet season. According to DOE-WQI, station at Melai River during dry season in 2020 is classified in Class II because the WQI value is 91.92 which is in the range 76.5-92.7, so that the water quality at this station is consider clean. While the Chini River during wet season in 2017 is classified

in Class III because the WQI value is 66.5 which is in the range 51.9-76.5 which is the index range is classified as slightly polluted. For Jemberau River during dry season in 2020 is classified as Class II because the WQI value is 83.3 which is in the range 76.5-92.7, so that the water quality at this station is consider clean. While, for Jemberau River during wet season in 2017 is classified as Class III because the WQI value is 75.98 which is in the range 51.9-76.5, which is the index range is classified as slightly polluted. Next, for Jerangking River and Gumum River for both season during 2020 and 2017 are classified in Class II because the WQI value are in the range of 76.5-92.7 which is the water quality is consider clean. The water pollution might be coming from the land use activities, agricultural activity and rainy season also give an impact toward water quality.

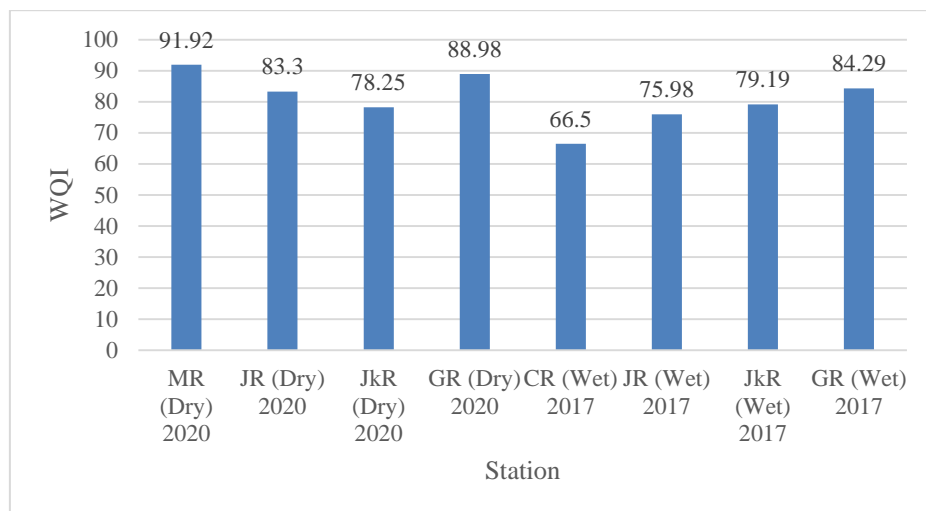


Figure 6. Water Quality Standard based on WQI at all stations during (dry-2020 and wet-2017)

Table 3 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 this data, the concentration of heavy metal in water samples is slightly higher according to permissible range of NWQS. This situation occur because of land use activities such as agricultural, mining, palm oil plantation, logging and also emission of waste from residential area. All of this activities can lead to increasing water pollution around this area.

Table 3. Result of heavy metals using AAS method during 2018 and 2019

| 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 4 shows the concentration in unit ppm and ppb of heavy metals in sample obtained at Jemberau River and Chini River during wet season 2017. These heavy metal levels are determined by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), two parameters carried out in laboratory which is Iron (Fe) and Manganese (Mn). Based on the result from Table 4, the heavy metal concentration in water sample are higher for Manganese (Mn) and Iron (Fe) for both stations. The concentration of Iron (Fe) are less than 0.1 ppm but it still higher compare to Manganese (Mn) in ppb unit. This indicated that the higher concentration for these heavy metal element was resulted from mining activity nearby affecting the increment of water pollution in that area.

Table 4. Result of heavy metals using method (ICP-MS) during 2017

| STATIONS | PARAMETER | RESULT | UNIT |
|----------------|----------------|------------------------------|------|
| Jemberau River | Iron (Fe) | Not Detected (Less than 0.1) | ppm |
| | Manganese (Mn) | 155.1 | ppb |
| Chini River | Iron (Fe) | Not Detected (Less than 0.1) | ppm |
| | Manganese (Mn) | 189.3 | ppb |

Table 5 shows the concentration in unit ppm and ppb of heavy metals in sample obtained at Melai River, Jemberau River, Jerangking River and Gumum River during dry season 2020. The highest heavy metal concentration in water sample for Iron (Fe) is at Gumum River which is 1.349 ppm while the highest heavy metal concentration in water sample for Manganese (Mn) is at Jemberau River which is 120.1 ppb. All of the tabulated data for heavy metals were recorded based on the water sample that taken at 22th February 2020. The data that has been recorded indicated that the higher concentration for these heavy metals element was resulted from the land use activity near the Jemberau River which is specifically known as mining activity that contribute the worse effect for water quality around the Tasik Chini.

Table 5. Result of heavy metals using method (ICP-MS) during 2020

| STATIONS | PARAMETER | RESULT | UNIT |
|------------------|----------------|--------|------|
| Melai River | Iron (Fe) | 0.8246 | ppm |
| | Manganese (Mn) | 76.86 | ppb |
| Jemberau River | Iron (Fe) | 0.6603 | ppm |
| | Manganese (Mn) | 120.1 | ppb |
| Jerangking River | Iron (Fe) | 1.317 | ppm |
| | Manganese (Mn) | 75.25 | ppb |
| Gumum River | Iron (Fe) | 1.349 | ppm |
| | Manganese (Mn) | 104.4 | ppb |

Based on the data tabulated in Table 3, Table 4, and Table 5 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. Besides, it also shows that, the presence of iron (Fe) and manganese (Mn) in water sample around Tasik Chini.

5. Conclusion

The current water quality status and classification for Melai River, Jemberau River, Jerangking River and Gumum River was determined based on National Water Quality Standards (NWQS) for Malaysia and Water Quality Index (WQI) from Department of Environment Malaysia. Based on the analysis that has been made, station at Melai River, Jemberau River, Jerangking River and Gumum River are classified as Class II during dry season in 2020 which is according to index range of WQI, all this station during dry season in 2020 was classified as clean. There is a lot of factor the give impact toward the water quality around Tasik Chini such as land use activity like mining activity. Besides, the water quality had been improving too because of the season itself. It is because, during the rainy season, the water will be disturbed and will be result the water become murky and will cause the concentration of heavy metal in the water to be increase. Tasik Chini should be treating well for better future. From the in-situ analysis and laboratory experiment, there is a lot of different reading of parameter concentration based on different location and seasons. Since the human activities such as mining had been controlled by the government, the water quality at Tasik Chini had been improve. Besides, the difference season give the different result too toward water quality and it shows that, during the dry season, water quality become improve and concentration of heavy metal become decrease. Since the rivers are classified as Class II, conventional treatment is required and that water are still safe for daily life uses. Besides, it also suitable for fishery and can support aquatic life.

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