# The Impact of Flood on Water Quality and Benthic Invertebrate in Rivers at Gua Musang, Kelantan


Shamsudin Mustafa Dawood[1,a*], Salmiati[1,b], Nor Zaiha Arman[1]

[1]Faculty of Civil Engineering, Universiti Teknologi Malaysia, Malaysia

[a*]shamsudin@live.utm.my, [b]salmiati@utm.my



**Keywords:** Water quality; Macrobenthos; Flood



**Abstract.** The aim of this study was to have a better understanding about the impact of flood to the ecosystem such as types of pollution and water quality level of rivers in Kelantan. This study was specifically carried out in a flooding prone area determine water quality level by using Water Quality Index (WQI) and Macrobenthos analysis to reach the objective of the experiment. In this study, samples from two major rivers in Gua Musang, Kelantan were chosen to be analyzed as they were just hit by a major flood recently, those two rivers are Sg. Nenggiri and Sg. Lebir. Samples from these two rivers were analyzed using Water Quality Index (WQI) and Macrobenthos analysis method so that a comparison can be carried out between the two methods and to identify the distribution of benthic invertebrate in the fauna. Results from the analysis were then compared to the water quality index before the flooding event given by Department of Environment (DOE). This study has achieved its objective by thorough and carefully analyzed results where the WQI and BWQI value were obtained and compared. WQI value for Tributary Sg. Nenggiri was 78.06 classified into class II with a slightly polluted river status while the BWQI value for this river was 6.07 also categorized into class II with rather clean status. Sg. Nenggiri and Sg. Relai on the other hand has a WQI value of 90.31 and 85.01, both are classified into class II with a clean river status while the BWQI shows a value of 6.63 and 6 with a rather clean status and belongs into class II. Sg. Paloh recorded a WQI value of 79.81, categorized into class II with a slightly polluted river status whereas the BWQI value for this river was 6.17 classified into class II with a rather clean status. From the comparisons made on WQI and BWQI we can deduce that both method showed a similar result with a slight indifference that did not affect the accuracy of the results.


## Introduction

Flood is a natural occurrence that happens when a piece of land or city submerged in water. When flood happens it can bring instability to the ecosystem and water quality due to the fact that flood carries along object like trees and rubbish from the land and settled in the bottom of the river causing disturbance to the aquatic habitat. Disturbance from flood is one of the most important forces structuring stream invertebrate and fish communities worldwide [1]. Flood is an annual catastrophe that happen in Malaysia during the monsoon period (October - March). The mechanism of flood starts when an area, usually a low lying area inundated in water due to river overflowing its bank. In Malaysia, there was no specific categorization of the flood because the downpour scattered throughout the year but it is often called as monsoonal, flash or tidal floods because the rain has the highest intensity during monsoon season. Besides that, floods were also categorized based on several other criteria such as place, characteristics, factors that initiate the flood, timing and the extent of the event. The main factor that often initiate flood in Malaysia was usually due to the spike in the runoff and rainfall intensity, downpour length and deficiency in drainage networks [2].

Flooding can cause major disturbances in aquatic habitat ecosystem due to several factors. Modification of river flow to due to flooding can affect the salinity, water temperature, pH, ionic structure of the water and lower the dissolved oxygen concentration. This could be harmful to the ecosystem because the existing species may compete with other species that better suited to the modified conditions which will eventually lead to mortality and decrement in the benthic and fish population.

Changes in the water quality parameters due to flood may also alter the standard quality of drinking water conditions. [2] The objective of this study is to determine and classify the water quality level based on water quality index, to classify the distribution and composition of benthic in fauna as biological indicator and to compare the water quality status between water quality laboratory analysis and biological monitoring in Gua Musang and its impact from a flooding event. The scope of this study is to investigates the water quality in four rivers in Gua Musang, Kelantan. The quality of the water body is determined by doing analysis on the samples according to the water quality parameters such pH, temperature, Dissolved oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (AN) and Total Suspended Solid (TSS).

**Previous Studies**

A comprehensive review of the influence of flood disturbance on the distribution of benthic invertebrates can be found in [1]. Benthic invertebrate are specifically chosen in environmental effects monitoring program because their range of movement is limited thus they can't avoid or run from pollution. Besides that, benthic invertebrate are also found lavishly in the river making it easier to be sampled all year long. Aquatic species usually have a life span of approximately one year, this provides researcher a good indication of the water quality over that period. In other words, their life span is long compared to the short term disturbance that occur [3].

The population of benthic invertebrates in river is often high but will decline if the communities are affected by pollution for a long period of time especially when anoxia (an absence or deficiency of oxygen reaching the tissues) occurs. The loss of benthic invertebrate can increase turbidity level because these organism filter suspended particles and increase the rates of sedimentation. Besides that, benthic communities are often used as biological indicators because they can provide information on environmental conditions either due to the sensitivity of single species (indicator species) or because of some features that makes them mix with environment [3]. The distribution of benthic invertebrate in the river is influenced by several physical parameters such as substrate composition, pH, water temperature, salinity and dissolved oxygen composition. Benthic communities can change if there are excessive nutrients in the river which will lead to eutrophication, and this has happened around the world [4]. Nutrients may at first stimulate the organism because more food is supplied however when the sediment increases the dissolved oxygen in the water depletes to a level that can results in mortality. Under extreme condition, enrichment in nutrient can cause a situation where the oxygen is completely absence, this will force the benthic invertebrate to leave the area and die. The area will then be occupied by species that have high tolerance of low oxygen concentration such as small polychaete worms, nematodes and clams. Furthermore, Modification of river flow to estuaries because of flood can modify the salinity, water temperature, pH, ionic structure of the water and lower the dissolved oxygen concentration.

Replacement of the existing species may occur due to the competition by the species that better suited to the modified conditions due to changes because of the flood [5]. The effect of disturbance and the importance of natural floods in creating an environmental heterogeneity have been studied all over the world. Large scale disruption caused by flood often depletes the lavishness of organism in the river but the colony usually recovers within a short period of time, often in just weeks or months. Stream insects are well known for its ability to survive floods in areas where the conditions have enabled the species to live after extinction such as stream margins, large stable surface coasts, zones of flow and sediments. However, this will depend on the species whether it possesses behavioral or morphological strategies to avoid death or displacement (such as seeking protection during the disruption) or are adjusted through physiological tolerance (such as Dipterans and Oligochaeta which are adapted to obtain low levels of dissolved oxygen) to the effects of disruption [6].

WQI has been considered as standard criteria for surface water classification based on several parameters used. This index is a numeric expression used to simplify the large data of water characterization into an integer that shows the pollution level of the water. The Department of Environment uses six parameters as a tool in determining the surface water quality in Malaysia, the six parameters are DO, BOD, COD, SS, Ammonia and pH [7]. WQI values make information more easily understood than a long list of integer values for a different set of parameters. Moreover, WQI also facilitate comparisons between different sampling sites and/or an event, they are considered better alternative in giving information to the audiences. When their specific limitations are taken into account WQI can be very useful in term of management and decision making because WQI provides a useful way to predict changes and trends based on several parameters [8]. Basically, WQI was established to evaluate the water quality and river classification in a more systematically way.

## Methodology

In order to meet the objectives of the experiment, two main test were conducted to investigate the water quality level and the distribution of the benthic organism in the river. The tests that were carried out are water sampling methods and macrobenthos sampling method. The water sampling method test were carefully penned out with proper equipment to determine and classify the quality of the water body based on six main parameters; Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids (SS), pH value, Ammonia Nitrogen (AN) and Dissolved Oxygen (DO).

### *Sampling Station*

This study was conducted in two of the main rivers in Gua Musang, Kelantan namely Sungai Nenggiri and Sungai Lebir. Table 1 shows the coordinate of the sampling station four rivers that are connected to the two main rivers which are Sg.Nenggiri, Tribituary Sg.Nenggiri, Sg. Relai and Sg. Paloh.

Table 1: Coordinates of The Sampling Site

| No | Site | Point | Longitude | Latitude |
|---|---|---|---|---|
| 1 | Sg. Nenggiri | 1 | 4.97024°N | 101.77144°E |
| 2 | Sg. Nenggiri | 2 | 4.96951°N | 101.77207°E |
| 3 | Tributary Sg. Nenggiri | 1 | 5.00942°N | 101.76010°E |
| 4 | Tributary Sg. Nenggiri | 2 | 5.00989 °N | 101.75955 °E |
| 5 | Sg. Relai | 1 | 5.23775°N | 102.25429°E |
| 6 | Sg. Relai | 2 | 5.23749°N | 102.28357°E |
| 7 | Sg. Paloh | 1 | 5.23775°N | 102.25429°E |
| 8 | Sg. Paloh | 2 | 5.23749°N | 102.28357°E |

### *In-Situ Analysis Method*

Four parameters were tested on the sampling site using a portable water quality device called as Multi-parameter YSI 550A. Those parameters that were tested on site are; pH, Dissolved Oxygen (DO), temperature and conductivity.

### *Laboratory Testing*

Laboratory analyses were conducted to determine the parameters that could not be tested at the sampling site. This analysis was important in order to get the most accurate profile of the water quality and the score of the benthic organism. Among of the parameters that were tested were; Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), and Ammoniacal Nitrogen (AN). Table 2 below showed the standard method used in determining the parameters mentioned above.

Table 2: Standard Method Used in Laboratory Testing

| Parameters | Method |
|---|---|
| Biological Oxygen Demand (BOD) | APHA 5210-B |
| Chemical Oxygen Demand (COD) | APHA 5220-C |
| Total Suspended Solid (TSS) | APHA 2540-D |
| Ammoniacal Nitrogen (AN) | APHA-NH3-BC |

***Water Quality Index (WQI)***

The index of water quality was calculated using Eq. (1) with each of its sub index can be computed based on Table 3.

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

Table 3: WQI Calculation Formula

| Parameter | Value | Sub index equation |
|---|---|---|
| COD | If $X = < 20$ | $SICOD = 99.1 - 1.33X$ |
| | For $X > 20$ | $SICOD = 103 \times [e]^{-0.0157X} - 0.04X$ |
| BOD | For $X = < 5$ | $SIBOD = 100.4 - 4.32X$ |
| | For $X > 5$ | $SIBOD = 108 \times [e]^{-0.055X} - 0.1X$ |
| AN | For $X = < 0.3$ | $SIAN = 100.5 - 105X$ |
| | For $0.3 < X < 4$ | $SIAN = 94 \times [e]^{-0.573X} - 5(X-2)$ |
| | For $X = > 4$ | $SIAN = 0$ |
| SS | For $X = < 100$ | $SISS = 97.5 \times [e]^{-0.00676X} + 0.05X$ |
| | For $100 < X < 1000$ | $SISS = 71 \times [e]^{-0.0016X} - 0.015X$ |
| | For $X = > 1000$ | $SISS = 0$ |
| pH | For $X < 5.5$ | $SIpH = 17.2 - 17.2X + 5.02X^2$ |
| | For $5.5 = < X < 7$ | $SIpH = -242 + 95.5X - 6.67X^2$ |
| | For $7 = < X < 8.75$ | $SIpH = -181 + 82.4X - 6.05X^2$ |
| | For $X = > 8.75$ | $SIpH = 536 - 77X + 2.76X^2$ |
| DO | $X = DO (mg/L)*12.6577$ | |
| | For $X = < 8$ | $SIDO = 0$ |
| | For $X > 8$ | $SIDO = = -0.395 + 0.030X^2$ $0.0002X^3$ |

***Invertebrate Method***

Invertebrate method is a biological method to determine the level of water pollution in a river. This method is effective because it does not need sophisticated equipment nor use any chemical in determining the pollution level. Benthic invertebrate is identified using the microscope and the total score are calculated based on BWQI. The formulae to calculate BWQI is as shown in Eq. (2).

$$\text{Biological Water Quality Index (BWQI)} = \frac{\text{Score of macrobenthos}}{\text{Types of macrobenthos}} \quad (2)$$

**Results and Discussions**

For a thorough analysis of the study on water quality of the rivers in Gua Musang, several key parameters of the WQI were conducted using in-situ and laboratory method. BOD and COD were tested in-situ and the rest were analyzed in the laboratory. The analysis of the invertebrates was done by calculating the score of the organisms in accordance of the Water Quality Biological Index (BWQI).

***Analysis of Water Quality Parameter***

The analysis results for the water samples includes DO, BOD, COD, SS, pH and AN to determine the profile of each parameter along the river.

*Dissolved Oxygen (DO)*. Dissolved Oxygen (DO) is one of the most important parameter in determining the water quality level of a river because it can influence the water quality index by 22% (DOE, 1986). Table 4 shows the DO value obtained in four rivers in Gua Musang that was sampled three times. Sample was obtained in June, august and September of 2015. Table 4 shows that Sg. Paloh has the most consistent value of DO averaging 8 mg/L and decrease slightly to 7.7 mg/L on the third sampling. The minimum DO concentration is 6.85 mg/L for sampling one at Sg.Nenggri and the maximum DO concentration is 9.85 mg/L recorded on the second sampling in tributary Sg. Nengiri.

Table 4: Analysis of Dissolved Oxygen (mg/L) Results

| Sampling | Station | | | |
|---|---|---|---|---|
| | **Sg.Nenggiri** | **Tributary Sg.Nenggiri** | **Sg.Relai** | **Sg.Paloh** |
| Sampling 1 | 9.6 | 9.6 | 9.7 | 8.1 |
| Sampling 2 | 9.7 | 9.9 | 9.0 | 9.0 |
| Sampling 3 | 6.9 | 8.1 | 7.4 | 7.7 |

Additionally, Figure 1 shows the trend graph of the dissolve oxygen content over the period of three months. The graph shows a decrement of DO content for all four stations. The graph also indicates a stagnant increase in the value of oxygen content between first sampling and second sampling and a major decrement in value between the second and third sampling. Overall, all these four stations are classified at class I in water quality index classification**.**

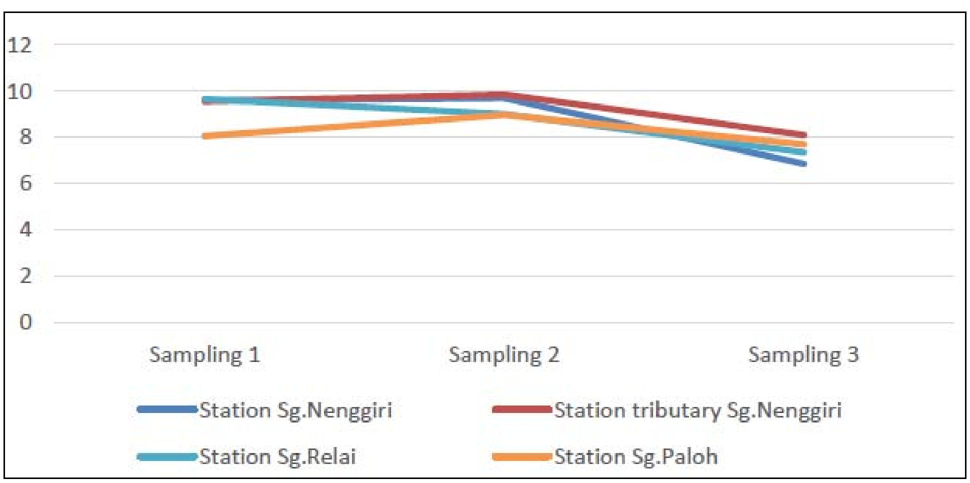


Figure 1: The graph of Dissolved Oxygen (DO) against sampling date at Gua Musang, Kelantan

*Biochemical Oxygen Demand (BOD)*. Biochemical Oxygen Demand is the main indicator of organic pollution in the river and it is interrelated with dissolved oxygen content. Theoretically, a decrease in the dissolved oxygen content means an increase in BOD value. According to DOE, BOD is the second most important factor in determining the WQI of a river because it can influence the index value by 19% (DOE,1986). Table 5 and Figure 2 showed the result and profile of the BOD at each of the sampling station in Gua Musang.

Table 5 indicated that the maximum value of BOD was recorded at the Sg.Paloh on the second sampling with the value of 14.5 mg/L which falls under class V. The minimum BOD Concentration was recorded on the third sampling at Sg. Paloh with a concentration of 1.5 mg/L. The trend graph shows a decreasing pattern of the BOD value over the period of the study in all four rivers and especially between the first and second sampling except for Sg. Paloh. Sg. Paloh recorded an odd pattern in which the BOD value increase drastically in between the first and second sampling and succumb to drastic decrement in sampling three**.**

Table 5: Analysis of Biological Oxygen Demand (mg/L) Results

| **Sampling** | **Station** | | | |
|---|---|---|---|---|
| | **Sg.Nenggiri** | **Tributary Sg.Nenggiri** | **Sg.Relai** | **Sg.Paloh** |
| Sampling 1 | 4.5 | 8.5 | 7.5 | 6.0 |
| Sampling 2 | 3.0 | 5.0 | 4.0 | 14.5 |
| Sampling 3 | 3.5 | 5.5 | 2.0 | 1.5 |

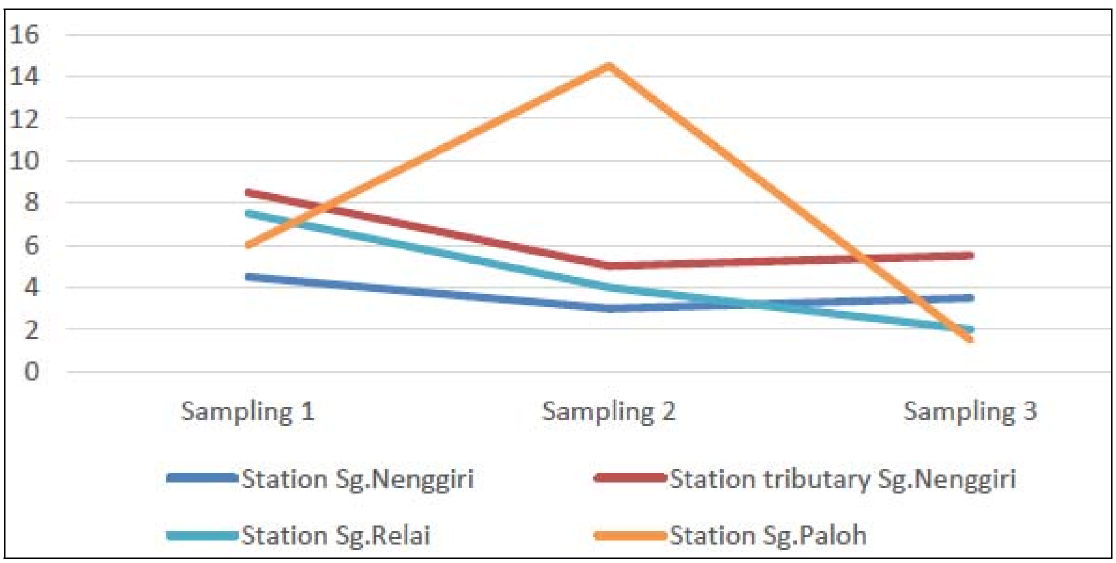


Figure 2: The Graph of Biological Oxygen Demand (BOD) Against Sampling Date at Gua Musang, Kelantan

*Chemical Oxygen Demand (COD)*. WQI is third most important parameter in determining the water quality index after dissolved oxygen and biochemical oxygen demand as it can influence the WQI by 16% sharing the same influence level as TSS (DOE, 1986). COD in a river usually range from 0 to 150 mg/L depending on several factors that were discussed in chapter 2. Table 6 shows the range of COD concentration at the sampling site that records an average concentration 6 to 13 mg/L which falls under class I. The minimum concentration of COD was shared by Sg. Relai and Sg. Paloh on the third sampling. Both of these concentrations were below 10 mg/L which was classified as class I in the water quality index. The maximum concentration of COD was recorded at Sg. Relai on the first sampling with a value of 12.5 mg/L. This value has exceeded the minimum requirement to be classified in class I thus making it to be listed in class II. The trend graph in Figure 3 indicates that the COD concentration is almost the same as BOD trend graph, the graph shows that all four rivers experienced a reduction in COD values at the end of sampling 3. Sg. Paloh once again recorded a pattern in which the value of COD increased drastically between sampling one and two and then decreased to 3 mg/L on the third sampling.

Table 6: Analysis of Chemical Oxygen Demand (mg/L) Results

| **Sampling** | **Station** | | | |
|---|---|---|---|---|
| | **Sg.Nenggiri** | **Tributary Sg.Nenggiri** | **Sg.Relai** | **Sg.Paloh** |
| Sampling 1 | 7.0 | 11.0 | 12.5 | 11.5 |
| Sampling 2 | 4.5 | 7.5 | 6.0 | 25.0 |
| Sampling 3 | 5.5 | 8.0 | 3.0 | 3.0 |

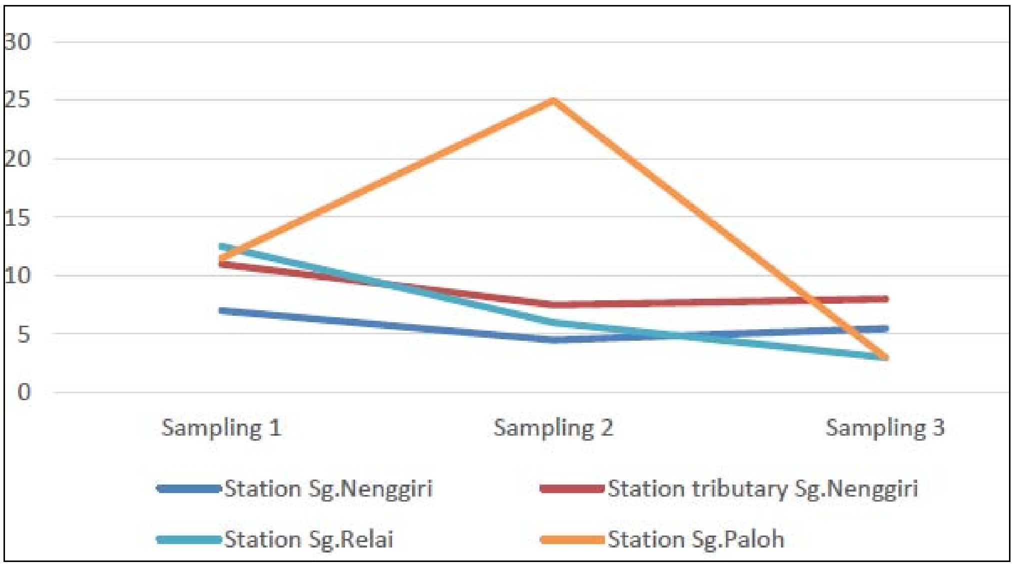


Figure 3: The Graph of Chemical Oxygen Demand (COD) Against Sampling Date at Gua Musang, Kelantan

*Total Suspended Solid (TSS)*. Total suspended solid sit on level with COD as the third most important parameters in determining the water quality of a river. DOE stated that TSS is accountable for 16% of the influence in WQI (DOE, 1986). Table 7 showed that the value of total suspended solid ranging from 19 mg/L to a staggering 202 mg/L throughout the study. The minimum concentration of 19 mg/L was recorded in Sg. Paloh on the third sampling dated while the maximum concentration also was recorded in Sg. Paloh on the second sampling.

Normally, a high source of total suspended solid was a result of solid and liquid waste that were dumped directly onto the river. A high concentration of TSS will affect the river aquatic life direct and indirectly because total suspended solid can increase turbidity and temperature of a river. Figure 4 shows that the total suspended solid value decreased drastically over the time in tributary Sg. Nenggiri from 198.5 mg/L to 34 mg/L. While in Sg. Paloh there was a drastic increment in sampling 2 from 72 mg/L to 202 mg/L and drop to 19 mg/L in sampling 3. These rivers average in class II of water quality index.

Table 7: Analysis of Total Suspended Solid (mg/L) Results

| **Sampling** | **Station** | | | |
|---|---|---|---|---|
| | **Sg.Nenggiri** | **Tributary Sg.Nenggiri** | **Sg.Relai** | **Sg.paloh** |
| Sampling 1 | 32.0 | 198.5 | 61.5 | 72.0 |
| Sampling 2 | 36.5 | 88.5 | 9.5 | 202.0 |
| Sampling 3 | 8.5 | 34.0 | 35.0 | 19.0 |

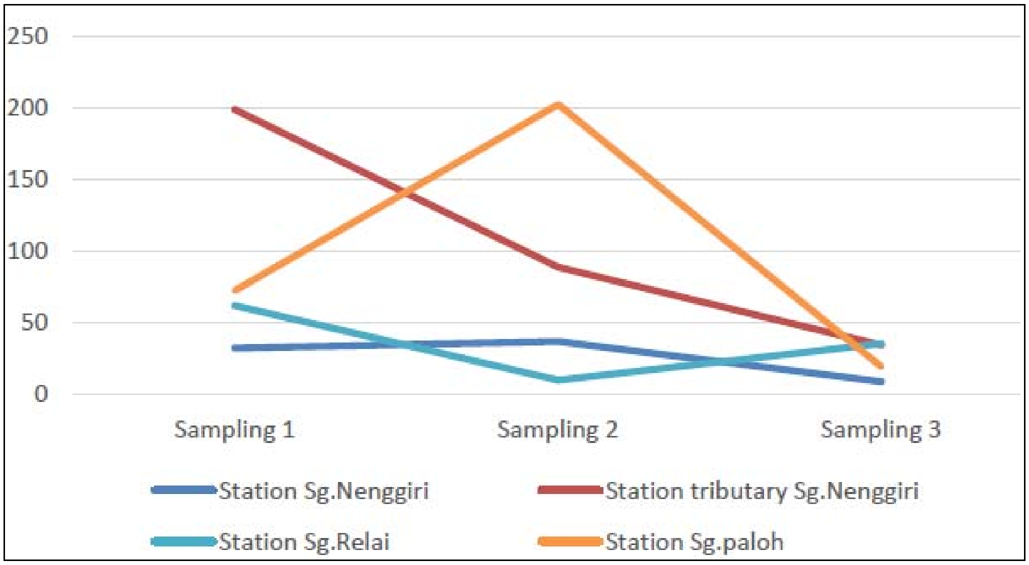

Figure 4: The Graph of Total Suspended Solid (TSS) Against Sampling Date in Gua Musang

*Ammoniacal Nitrogen (AN).* Ammoniacal Nitrogen (AN) is the second least influential parameter in determining the water quality index as it is only 15% responsible of the water quality (DOE,1986). Ammoniacal is considered as class I if it is below 0.1 mg/L and class V if it exceeds 2.7 mg/L. Table 8 indicates the value of the AN at the sampling site which range from 0.17 to 3.03 mg/L. The minimum value of AN was recorded at Sg. Nenggiri on the first and second sampling which is 0.17 mg/L and the maximum AN concentration was recorded at tributary Sg. Nenggiri on the second sampling. This maximum value falls has exceeded 2.7 thus it falls on class V.

A large number of pollutants caused by human such as human waste and fertilizer that flows onto the river might be the reason of the sudden increase in the AN value of tributary Sg. Nenggiri. The major source of AN is from animal, agriculture and domestic waste (Kasan, 2006). Figure 5 shows the trend of the AN concentration over the period of the study, tributary Sg. Nenggiri recorded the biggest drop of AN concentration from 3.03 to 0.22 mg/L on the third sampling. AN concentration at Sg. Nenggiri remains consistent with an average of 0.19 mg/L that was classified under class II.

Table 8: Analysis of Ammoniacal Nitrogen (mg/L) Results

| Sampling | Station | | | |
|---|---|---|---|---|
| | **Sg.Nenggiri** | **Tributary Sg.Nenggiri** | **Sg.Relai** | **Sg.Paloh** |
| Sampling 1 | 0.17 | 3.03 | 1.05 | 0.69 |
| Sampling 2 | 0.17 | 1.74 | 0.29 | 1.80 |
| Sampling 3 | 0.20 | 0.22 | 0.78 | 0.80 |

*pH.* pH is the least influential parameter in determining the water quality as it only hold up 12% of the total which is relatively low compared to other parameters mentioned above. Table 9 shows the result obtained on the sampling site regarding the pH which clearly indicates that all pH values are averaging 6.7 which was slightly acidic and almost neutral. The minimum pH was recorded in tributary Sg. Nenggiri on the first sampling with a pH of 6.68 while the maximum pH was recorded at Sg. Relai on the third sampling with a pH of 6.9. The pH values of all sampling station were classified in class II as it ranged from 6-7, anything that ranges above 7 are considered as class I. The trend graph in Figure 6 indicated that pH in all sampling station increases except for station in Sg. Paloh. Three other remaining rivers showed and increment of averaging 0.1. The amount of pH was stable throughout the study with a slight increment or decrement.

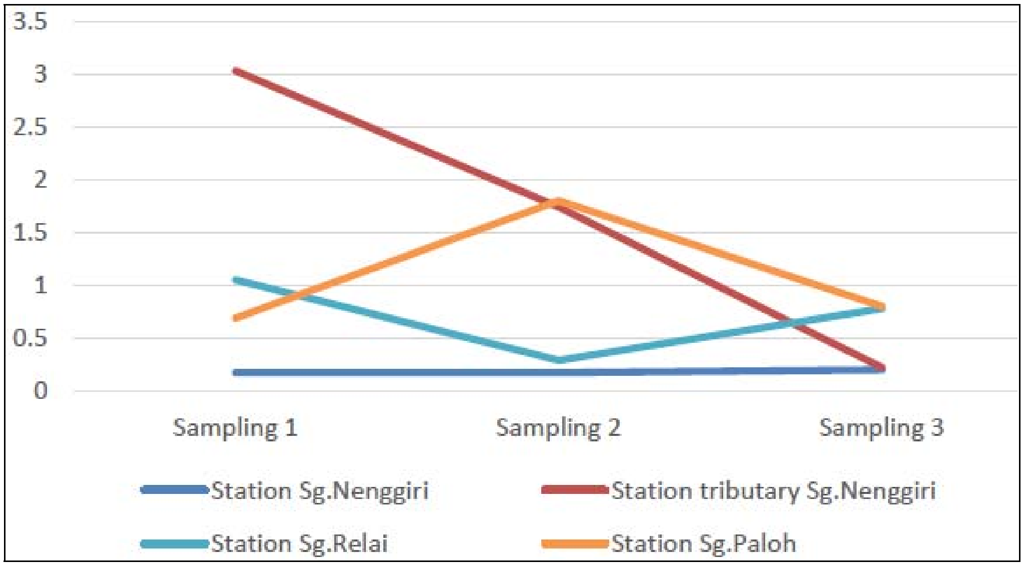

Figure 5: The Graph of AN Against Sampling Date at Sampling Stations in Gua Musang, Kelantan

Table 9: Analysis of pH (mg/L) Results

| Sampling | Station | | | |
|---|---|---|---|---|
| | Sg.Nenggiri | Tributary Sg.Nenggiri | Sg.Relai | Sg.Paloh |
| Sampling 1 | 6.69 | 6.68 | 6.74 | 6.80 |
| Sampling 2 | 6.78 | 6.77 | 6.80 | 6.76 |
| Sampling 3 | 6.79 | 6.79 | 6.82 | 6.80 |

***Water Quality Index Analysis***

The value of water quality index was obtained by determining the sub index value of each parameter which were; SIpH, SIDO, SIBOD, SICOD, SISS and SIAN. WQI is a good indicator in determining whether the water body has improved or deteriorating. Table 10 shows the value of sub index of parameter and WQI of the four sampling site that was recorded on 2/6/2015. The value of WQI in all four rivers ranged between70 to 80, majority of the rivers are classified in class II which is slightly polluted except for Sg. Nenggiri which was categorized in class II with a clean status.

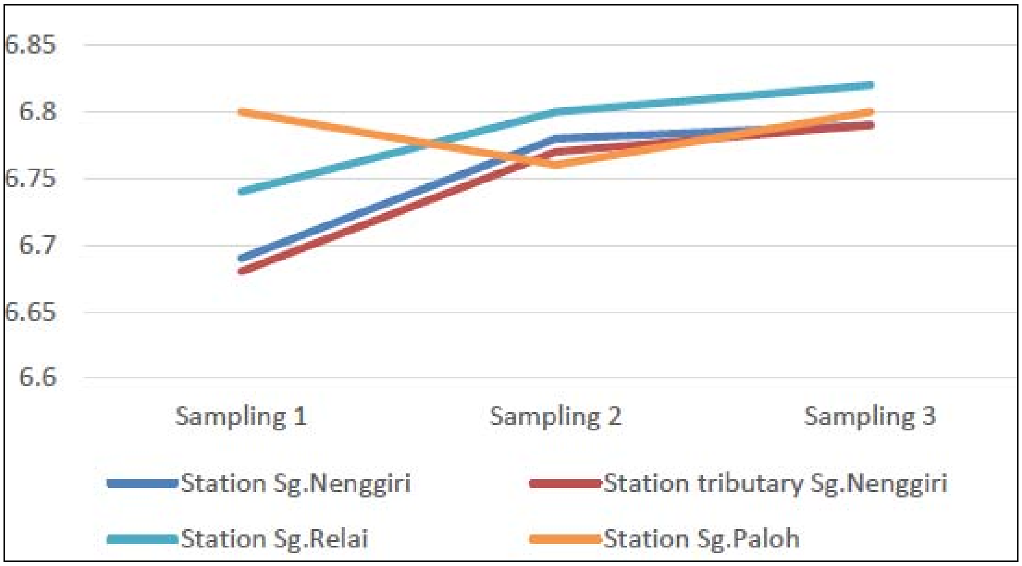

Figure 6: The Graph of pH Against Sampling Date at Gua Musang, Kelantan

Table 10: Status of WQI And Sub Index for Rivers in Gua Musang for Sampling 1

| Station | SIDO | SIBOD | SICOD | SIAN | SISS | SIpH | WQI | Class | Status |
|---|---|---|---|---|---|---|---|---|---|
| Tributary Sg. Nenggiri | 100 | 66.84 | 84.47 | 11.42 | 48.71 | 98.37 | 69.53 | III | SP |
| Sg. Nenggiri | 100 | 81.37 | 89.79 | 83.18 | 80 | 98.31 | 88.95 | II | C |
| Sg. Relai | 100 | 70.99 | 82.48 | 46.88 | 67.61 | 98.67 | 78.37 | II | SP |
| Sg. Paloh | 100 | 76.02 | 83.81 | 56.91 | 63.53 | 98.98 | 80.43 | II | SP |

Table 11 shows the value of Sub Index and water Quality Index (WQI) for sampling made on 4$^{th}$ of august 2015. From the table we can see that there is slight improvement on WQI compared to the first sampling where Sg, Nenggiri, tributary Sg.Nenggiri and Sg. Relai recorded an improvement, only Sg. Paloh water body condition deteriorated to 80.43 from 70.11. All the rivers recorded an average WQI of 70 to 80 which falls under class II except for Sg. Nenggiri. Sg. Nenggiri recorded a whooping WQI of 90.45 highest in all three sampling with a quality status of clean. Besides that, Sg.Relai also record an improvement clinching a clean rivers status from slightly polluted by having a WQI of 89.80.

Table 12 shows the value of sub index and WQI recorded on the third sampling on 29th of September 2015. Data for this sampling showed a massive improvement in term of WQI where all four rivers are classified in class II with all of them recorded WQI above 80 with a clean river status. Sg. Nenggiri maintained the same value as in sampling 2 with a value of 91.54 highest among other rivers and classified in class II. Three other rivers which are; Tributary Sg.Nenggiri , Sg. Relai and Sg. Paloh averaging a WQI of 87 with a clean river status compared to slightly polluted in sampling 1 and 2.

Table 11: Status of WQI And Sub Index for Rivers in Gua Musang for Sampling 2

| Station | SIDO | SIBOD | SICOD | SIAN | SISS | SIpH | WQI | Class | Status |
|---|---|---|---|---|---|---|---|---|---|
| Tributary Sg. Nenggiri | 100 | 80.55 | 89.13 | 33.09 | 58.06 | 98.88 | 77.68 | II | SP |
| Sg. Nenggiri | 100 | 87.71 | 93.12 | 83.18 | 78 | 98.83 | 90.46 | II | C |
| Sg. Relai | 100 | 83.48 | 91.12 | 71.85 | 91.91 | 98.98 | 89.80 | II | C |
| Sg. Paloh | 100 | 55.48 | 70.49 | 34.74 | 57.67 | 98.77 | 70.11 | III | SP |

Table 12: Status of WQI And Sub Index for Rivers in Gua Musang for Sampling 3

| Station | SIDO | SIBOD | SICOD | SIAN | SISS | SIpH | WQI | Class | Status |
|---|---|---|---|---|---|---|---|---|---|
| Tributary Sg.Nenggiri | 100 | 78.13 | 88.46 | 75.83 | 79.58 | 98.93 | 86.98 | II | C |
| Sg. Nenggiri | 100 | 85.6 | 91.79 | 79.5 | 92 | 98.93 | 91.55 | II | C |
| Sg. Relai | 97.96 | 91.94 | 95.11 | 54.02 | 78.88 | 99.07 | 86.85 | II | C |
| Sg. Paloh | 100 | 94.06 | 95.11 | 53.58 | 86.71 | 98.98 | 88.88 | II | C |

Table 13 shows the value of average WQI value for all three sampling. The data shows that Sg. Nenggiri has the highest value of WQI with a value of 90.31 classified into class II with a clean river status while Tributary Sg.Nenggiri had the lowest WQI value with a value of 78.06 an a slightly polluted river status.

Table 13: Status of Mean Water Quality Index (WQI) For Rivers in Gua Musang

| Station | WQI | Class | Status |
|---|---|---|---|
| Tributary Sg. Nenggiri | 78.06 | II | SP |
| Sg. Nenggiri | 90.32 | II | C |
| Sg. Relai | 85.01 | II | C |
| Sg. Paloh | 79.81 | II | SP |

***Comparison of WQI Before and Post Flood***

Sg. Nenggiri and Sg. Lebir were the two major rivers where all sampling sites in this study were located, Sg. Nenggiri and tributary Sg. Nenggiri were connected by Sg.Nenggiri while Sg. Relai and Sg. Paloh are connected by Sg. Lebir. On 15$^{th}$ of December 2015 these two major rivers were hit with a major flash flood that was considered as the worst flood in decades. Table 14 shows the comparison of WQI value in these two major rivers before and after the incident happened taken from DOE Environmental Quality Report 2014.

Table 14: Comparisons of Water Quality Status During Pre-Flood and Post-Flood Event

| River | 2013 | | | 2014 | | | This study | | |
|---|---|---|---|---|---|---|---|---|---|
| | Score | Class | Category | Score | Class | Category | Score | Class | Category |
| Sg.Nenggiri | 86 | II | C | 84 | II | C | 84.19 | II | C |
| Sg. Lebir | 87 | II | C | 82 | II | C | 82.41 | II | C |

Based on Table 14, it can be seen that the WQI is almost the same as the value before flood. Sg. Nenggiri recorded WQI value of 84.19 classified into class II with a clean river status while Sg. Lebir has a WQI value of 82.41 categorized into class II with a clean river status. Supposedly the value of WQI after flood should be lower than the value of WQI before flood, we believe that this study recorded a similar WQI value than before flood because the study was only conducted for three months and it didn't start straight away after the flood incident happened. Further recommendations in getting a more accurate result are given in the conclusion of this article.

***Invertebrate Analysis***

Invertebrate is an easy and effective way in determining the quality of water body because it does not use expensive tools and complicated procedure. Invertebrate analysis can be done by all sorts of ages by using basic equipment and simple calculations to determine the water quality without the need of using dangerous chemicals. Figure 7 shows the number of invertebrate type in all four rivers on 2$^{nd}$ of June 2015, it could be clearly seen that Sg.Nenggiri had the abundance of invertebrates with odonata, decapoda, hemiptera, plecoptera, gastropoda and ephemeroptera all present in the river.

Table 15 shows the total score obtain by each river and the BWQI index. The calculation of BWQI can be found by dividing the total score and number of animal types. Sg.Nenggiri got the highest BWQI value which is 7 and classified into class II with a status of rather clean. Tributary Sg. Nenggiri had the lowest BWQI with a total score of 23 and 5.8 for BWQI. All the four rivers were classified into class II with a status of rather clean.

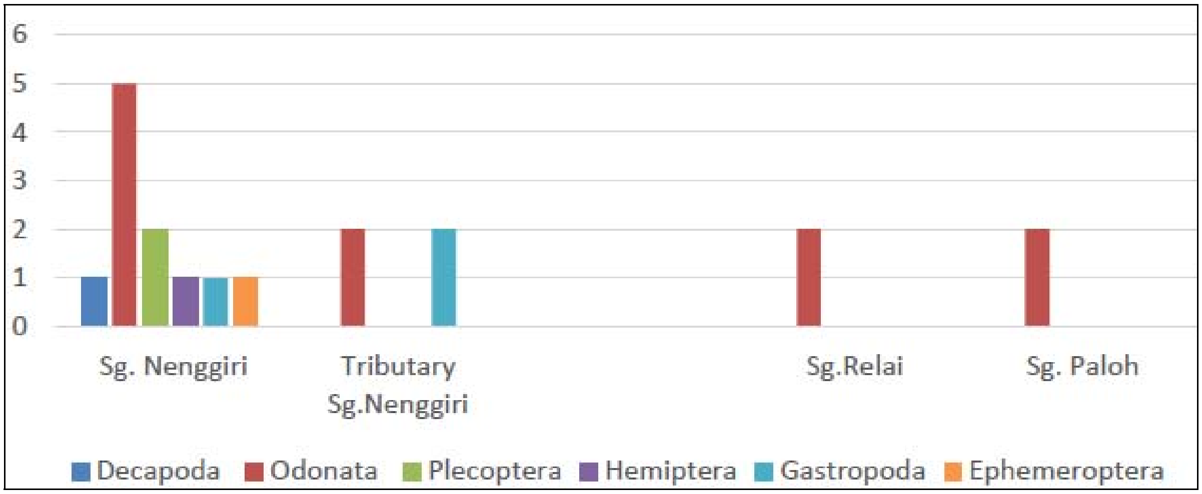

Figure 7: Number of Invertebrate Type for Sampling 2

Table 15: BWQI Value for Rivers in Gua Musang for Sampling 2

| Station | Total Score | No. of Animal Types | BWQI | Status | Level |
|---|---|---|---|---|---|
| Tributary Sg. Nenggiri | 23 | 4 | 5.8 | Rather clean | 2 |
| Sg.Nenggiri | 77 | 11 | 7 | Rather clean | 2 |
| Sg. Relai | 12 | 2 | 6 | Rather clean | 2 |
| Sg. Paloh | 12 | 2 | 6 | Rather clean | 2 |

Figure 8 below shows the type of benthic invertebrate that was recorded on $4^{th}$ of august 2015. This time the chart shows a much more abundance of invertebrate in other rivers compared to the first sampling. Sg. Nenggiri still leads the pole with the highest number of orders with five orders compared to Tributary Sg. Nenggiri (4), Sg. Relai (1) and Sg. Paloh (3). Highest number of odonata type was found in Tributary Sg. Nenggiri with total four type of odonata invertebrate. Total four orders of invertebrates have been found in Sg. Nenggiri compared to the first sampling that only had 2. Odonata, Decapoda, Hemiptera and Gastropoda were all found in the river.

Meanwhile, Table 16 below shows the total score of benthic invertebrate and BWQI index in the sampling site on 4th of August 2015. Highest BWQI was recorded at Sg.Nenggiri with a value of 6.9, a 0.1 decrement compared to the first sampling. Sg.Paloh recorded an increment in the BWQI value compared to the first sampling jumping up to 6.5 from 6. Both Sg. Relai and Sg. Paloh maintained the same BWQI value for both samplings. All rivers were classified under class II with a rather clean status. Sg. Nenggiri had the highest total score of invertebrate with a value of 55 however it was much less compared to the 77 in the first sampling. Sg.Paloh meanwhile recorded a total score of 26 a huge number of increment from the first sampling which was only 12.

Table 16: BWQI Value for Rivers in Gua Musang for Sampling 3

| Station | Total Score | No. of Animal Types | BWQI | Status | Level |
|---|---|---|---|---|---|
| Tributary Sg.Nenggiri | 43 | 7 | 6.1 | Rather clean | 2 |
| Sg.nenggiri | 55 | 8 | 6.9 | Rather clean | 2 |
| Sg. Relai | 12 | 2 | 6.0 | Rather clean | 2 |
| Sg. Paloh | 26 | 4 | 6.5 | Rather clean | 2 |

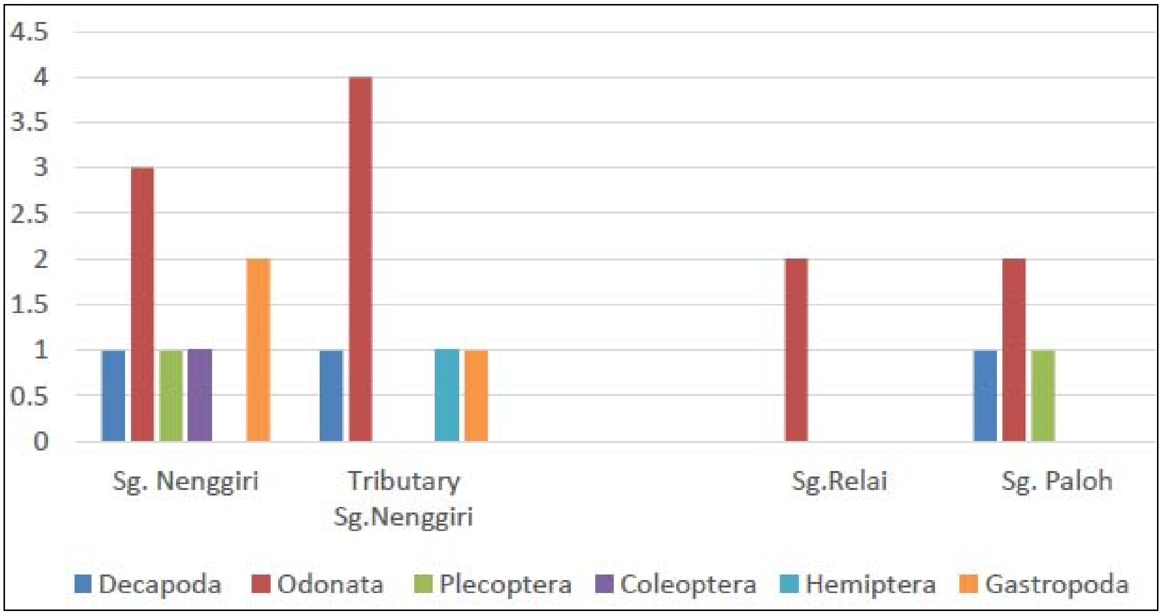


Figure 8: Number of Invertebrate Type For Sampling 2

Figure 9 shows the number of invertebrate type on 29th of September 2015, it can be seen from the chart that Sg.Nenggiri suffered a huge loss of invertebrate order compared to the first and second sampling which at least have 5 orders compared to three in this sampling. Sg. Nenggiri records an improvement with four orders and had the highest number of type of odonata sharing it with Sg. Paloh (2). Overall, this sampling showed a pattern of decrement in the number of invertebrate compare two the other two which resulted in a lower BWQI.

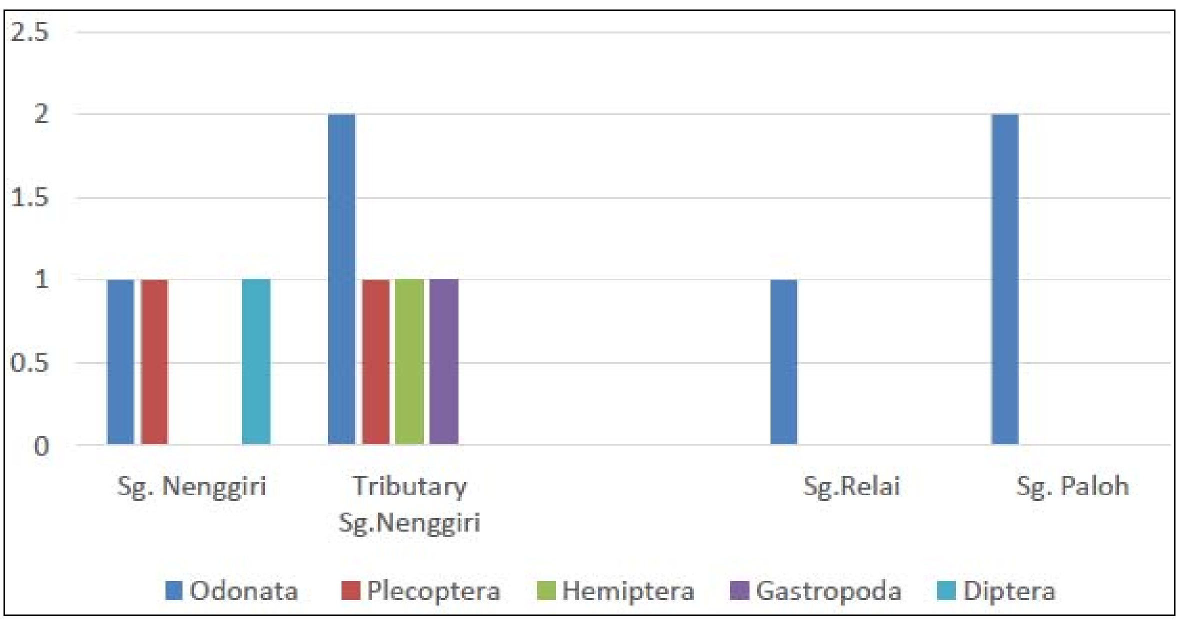


Figure 9: Number of Invertebrate Type for Sampling 3

Table 17 shows the total score of invertebrate and BWQI value for third sampling dated 29th of September 2015. This sampling showed an enormous reduction of total score in three rivers except for Tributary Sg. Nenggiri.Tributary Sg. Nenggiri shows an improvement in the total score from 23 in the second sampling to 33 in the third.Sg. Nenggiri showed a massive drop in the total score from 55 to 18. All in all, the BWQI of all rivers except for Tributary Sg. Nenggiri degraded slightly but still in class II with a rather clean status. Tributary Sg. Nenggiri recorded a 6.6 of BWQI value which was much better compared to the first two samplings. Sg. Relai is the only river that remains constant with a BWQI value of 6 in all three samplings. Table 18 on the other hand shows the average BWQI value for all three sampling, from the table it could be seen that Sg.Nenggiri has the highest value of BWQI with a value of 6.63 classified in class II with a rather clean status while Sg. Relai has the lowest value of BWQI with a value of 6 classified in class II with a rather clean status.

Table 17: BWQI Value for Rivers in Gua Musang For Sampling 3

| Station | Total Score | No. of Animal Types | BWQI | Status | Level |
|---|---|---|---|---|---|
| Tributary Sg.Nenggiri | 33 | 5 | 6.6 | Rather clean | 2 |
| Sg.nenggiri | 18 | 3 | 6 | Rather clean | 2 |
| Sg. Relai | 6 | 1 | 6 | Rather clean | 2 |
| Sg. Paloh | 12 | 2 | 6 | Rather clean | 2 |

Table 18: Mean BWQI Value for Rivers in Gua Musang, Kelantan

| Station | BWQI | Status | Level |
|---|---|---|---|
| Tributary Sg.Nenggiri | 6.17 | Rather clean | 2 |
| Sg.nenggiri | 6.63 | Rather clean | 2 |
| Sg. Relai | 6.00 | Rather clean | 2 |
| Sg. Paloh | 6.17 | Rather clean | 2 |

***Comparison of WQI and BWQI***

Table 19, 20 and 21 shows the results that were analyzed using the laboratory analysis and analysis of invertebrates for sampling that was done on 2nd of June 2015, 4th of August 2015 and 29th of September 2015 respectively. From this analysis we can conclude that there was a slight difference in Water Quality Index (WQI) and Biological Water Quality Index (BWQI).

Table 19 shows that Tributary Sg. Nenggiri had a WQI value of 69.52 that was classified into class II with a slightly polluted status while the BWQI value for the same river on a same sampling date showed a value of 5.8 with a rather clean status and classified in level II. All in all, the WQI and BWQI results showed a slight difference that would not affect the results significantly, a WQI value will show the more accurate results because it has analyzed more sub-indices thus making it more reliable. In conclusion, it can obtain the water quality and river pollution status using both method mentioned above with a slight difference in results.

Table 22 shows the mean WQI and BWQI value for all three samplings, from this result it could be seen that Sg. Nenggiri had the highest WQI value with a value 90.31 and classified into class II with a clean river status while Tributary Sg. Nenggiri had the lowest WQI value with a value of 78.06 and classified into class II with a slightly polluted river status. BWQI value for both of these rivers were 6.63 and 6.07 respectively, both of these rivers were classified into class II with a rather clean status.

Table 19: Results of WQI and BWQI at Sampling Site on 2nd Of June 2015

| Sampling Site | WQI | Class | Status | BWQI | Status | Level |
|---|---|---|---|---|---|---|
| Tributary Sg.Nenggiri | 69.5258 | III | Slightly polluted | 5.8 | Rather clean | II |
| Sg. Nenggiri | 88.9457 | II | Clean | 7 | Rather clean | II |
| Sg.Relai | 78.3749 | II | Slightly polluted | 6 | Rather clean | II |
| Sg.Paloh | 80.4323 | II | Slightly polluted | 6 | Rather clean | II |

Table 20: Results of WQI and BWQI at Sampling Site on 4th Of August 2015

| Sampling Site | WQI | Class | Status | BWQI | Status | Level |
|---|---|---|---|---|---|---|
| Tributary Sg.Nenggiri | 77.684 | II | Slightly polluted | 6.1 | Rather clean | II |
| Sg. Nenggiri | 90.4575 | II | Slightly polluted | 6.9 | Rather clean | II |
| Sg.Relai | 89.8011 | II | Clean | 6 | Rather clean | II |
| Sg.Paloh | 70.1102 | III | Slightly polluted | 6.5 | Rather clean | II |

Table 21: Results of WQI and BWQI at Sampling Site on 29th Of September 2015

| Sampling Site | WQI | Class | Status | BWQI | Status | Level |
|---|---|---|---|---|---|---|
| Tributary Sg.Nenggiri | 86.9772 | II | Clean | 6.6 | Rather clean | II |
| Sg. Nenggiri | 91.5454 | II | Clean | 6 | Rather clean | II |
| Sg.Relai | 86.8496 | II | Clean | 6 | Rather clean | II |
| Sg.Paloh | 88.8772 | II | Clean | 6 | Rather clean | II |

Table 22: Results of Mean WQI and BWQI at Rivers in Gua Musang, Kelantan

| Sampling Site | WQI | Class | Status | BWQI | Status | Level |
|---|---|---|---|---|---|---|
| Tributary Sg.Nenggiri | 78.06 | II | SP | 6.07 | Rather clean | II |
| Sg. Nenggiri | 90.31 | II | C | 6.63 | Rather clean | II |
| Sg.Relai | 85.01 | II | C | 6 | Rather clean | II |
| Sg.Paloh | 79.81 | II | SP | 6.17 | Rather clean | II |

## Conclusion

This study has achieved its objectives and purpose through the analysis of in-situ and laboratory results. The analyses that were carried out had presented a more detailed study on the current water quality status of Sg. Nenggiri, Tributary Sg.Nenggiri, Sg. Relai and Sg. Paloh. Based on this study, there are several conclusions that can be made on the analysis. From the laboratory and in-situ analysis that were made in determining the water quality profile of the river using the Water Quality Index (WQI) and Biological Water Quality Index (BWQI), we can conclude that the water quality of Sg. Nenggiri and Sg. Lebir which are the major rivers in the sampling site has been affected by the flood that happens, as we could see from sampling one the water quality level is lower than pre flood WQI before it gradually increases in sampling two and three. This analysis also shows a slight indifference in river pollution status of the river between Water Quality Index (WQI) and Biological Water Quality Index (BWQI) method. The samples from the river were analyzed by obtaining the value of six parameters which are biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), ammonia nitrogen (AN), pH and dissolved oxygen (DO). These values were used in the classification of the river by changing them into sub-indices and then used in the calculation of WQI. Although physical and chemical variables are commonly used to determine water quality, these parameters by themselves can only express the conditions of the water body at the moment of the sampling. In comparison to water quality index, invertebrate analysis can give information about the water quality of a water body for a longer period of time. The composition and distribution of macrobenthos as biological indicator is vital in determining the quality status of a river. From the invertebrate analysis, the composition of macrobenthos in the sampling site that consist of eight benthos families, those families were Decapoda, Odonata, Plecoptera, Hemiptera, Gastropoda, Ehphemeroptera, Coleoptera and Diptera. From this analysis, we can conclude that the rivers still can support benthic invertebrate even though the rivers are not classified in class I, this is proven by the abundance of macrobenthos in the samples.

For the purpose of ensuring a more accurate result in future studies, the study should be conducted for a longer period of time. The following below are some other recommendations for future study.

i. Adding more water quality parameters such as heavy metal and phosphate.
ii. Take a few samples for each station.
iii. Prolonging the sampling event to identify the actual distribution of benthic invertebrates.
iv. Increasing the number of tributary sampling at the known point source pollution

**References**


[1] Effenberger, M., Sailer, G., Townsend, C.R. and Matthaei, C.D., Local disturbance history and habitat parameters influence the micro-distribution of stream invertebrates, Freshwater Biology. 51(2) 2006 312-332.

[2] Chan, N.W., Impacts of Disasters and Disaster Risk Management in Malaysia: The Case of Floods, Resilience and Recovery in Asian Disasters. 2014 239-265.

[3] Beatty, J.M., McDonald, L., Westcott, F.M. and Perrin, C.J., Guidelines for Sampling Benthic Invertebrates in British Columbia Streams, 2006.

[4] Kumar, P. and Khan, A., The distribution and diversity of benthic macroinvertebrate fauna in Pondicherry mangroves, India, Aquat Biosyst Aquatic Biosystems. 9(1) 2013 15.

[5] Peirson, W.L., Bishop, K., Van Senden, D., Horton, P.R. and Adamantidis, C.A., Environmental Water Requirements to Maintain Estuarine Processes, Environmental Flows Initiative Technical Report Number 3, Commonwealth of Australia, Canberra, 2002.

[6] Lake, P.S., Disturbance, patchiness, and diversity in streams, Journal of the North American Benthological Society. 19(4) 2000 573-592.

[7] Naubi, I., Zardari, N.H., Shirazi, S., Ibrahim, F. and Baloo, L., Effectiveness of Water Quality Index for Monitoring Malaysian River Water Quality, Polish Journal of Environmental Studies. 25(1) 2016 231-239.

[8] Department of Irrigation and Drainage, Ministry of Natural Resources and Environment Malaysia. Water Resources Publication No.21. Study on The River Water Quality Trends and Indexes in Peninsular Malaysia, 2009.