The Impact of Flooding on Water Quality and Macrobenthic in Fauna at Rivers in Kuala Krai, Kelantan

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Abstract: A major flood have occurred in December 2014 that hit Kelantan. The floods have brought some changes to the environment and the ecosystem, especially to rivers around Kuala Krai, Kelantan. This study focused at four locations around Kuala Krai rivers, namely Sg. Manik Urai 1, Sg. Manik Urai 2, Sg. Durian and Sg. Geh. The objective of this study was to define and classify the water quality index (WQI). It is to determine the quality of water based on biological indicators (BWQI) and to compare the status of water between laboratory analysis and biological monitoring and determining the impact of floods on the river in Kuala Krai, Kelantan. Quality of water involved was assessed based on six key parameters of water quality index, i.e. Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrogen Ammonia (NH3N), pH and Suspended Solids (SS). Evaluation studies conducted through the collection and identification of biological indicators that comprise the macrobenthic based Biological Water Quality Index (BWQI). Based on studies conducted at the rivers near Kuala Krai, Kelantan, the average level of water quality index was in class II. Average water quality index and an average of Biological Water Quality Index (BWQI) was found to be in class II. In this study, the level of water quality played an important role on the changing lives of macrobenthos. Therefore, all parties must play an important role in improving the quality of water in each river. The management of this river should be more effective and accountable to the beauty and cleanliness of the river so that it can be benefited for future generations.

Introduction

Heavy rain is a leading cause of natural disasters, especially those related to flood-prone in the world. Normally the event of heavy rain and strong winds happens every year during the monsoon season from mid December 2014 until early January 2015 that affected most parts of Malaysia and lead the cause of the flooding in the East Coast - Terengganu, Pahang and Kelantan. The 2014 flood was the most significant and largest recorded flood in the history of Kelantan. The floods were caused by several factors. Rain continued without stopping and resulted in a flood. In low-lying areas, rain water will flow into the river. River filled with water will overflow, causing lowland covered with water. Besides that, urbanization was also affecting water flows especially in low-lying areas. In the past, creeks and valleys made the water flow, now the area has been covered with soil. When it rains, water will flow from the hills to the low areas and became stagnant. The water will increase and flash floods will occur. Floods could influence water quantity by affecting quality in one of two ways. Floods will either increase contaminants and sediments from urban and agricultural runoff during high rainfall causing a decrease in water quality. Or the high rainfall could increase a water body’s volume thereby diluting contaminants and pollutants, this will either improve water quality or have no significant impact on water quality. In general, this study was to achieve several objectives. The objectives were to determine and classify water quality level based on water quality index (WQI). It was also to determine water quality associated based on biological indicator (BWQI) and to compare water status between laboratory analysis and biological monitoring and determine the impact of flooding at rivers in the Kuala Krai, Kelantan. The study includes research on water quality and aquatic habitat ecosystem in Sg. Kuala Krai, Kelantan which flows after the big floods in 2015. While floods did a lot of environmental damage on land and water, Sg. Kuala Krai farmland and residential population as a whole has been destroyed by the floods. This will be a cause of serious disruption to the diversity of aquatic life such as invertebrate communities due to residues resulting from agricultural waste, garbage, feces and so the rest of the silt and water soluble at Sg. Kuala Krai during the flood. This study looked into the quality of water through the water quality index (WQI) through some physical and chemical parameters. The study was also conducted with regard to the assessment of the biological parameters of macrobenthos. The three main characteristics of water quality were done in order for the results of this study to be more comprehensive and accurate.

Previous Studies

Floods had a greater effect on benthic invertebrates resistance in the stream (stream bed dominated by bedrock and boulders), apparently due to the high presence of loose substrata overlaying bedrock and the higher scouring of sediment in this stream. It appears that the flood disturbances in the stream were too strong to find an increase in resistance as substrata size increased. The lack of a statistically significant effect of woody debris removal may imply that the composition and stability of inorganic substrata have more influence on invertebrate resistance to floods than woody debris at the reach scale in these headwater streams dominated by relatively stable substrata [1].

A river may be unsafe include by debris, mud or water and mud stains that indicate the river was flooded; erosion or instability in the ground surface around the river; unusual odor and taste or appearance of the river water [2]. Widespread consequences of water pollution upon ecosystems include species mortality, biodiversity reduction and loss of ecosystem services. Some consider that water pollution may occur from natural causes such as sedimentation from severe rainfall events; however, natural causes, including volcanic eruptions and algae blooms from natural causes constitute a minute amount of the instances of world water pollution [3].

Dissolved oxygen concentration is a key parameter for characterizing natural and wastewaters and for assessing the global state of the environment in general. The decrease of dissolved oxygen levels in the world's oceans, which is becoming increasingly obvious, is expected to have an impact on the whole ecosystem of the Earth, including the carbon cycle and the climate [4]**.** The amount of dissolved oxygen needed varies from creature to creature. Bottom feeders, crabs, oysters and worms need minimal amounts of oxygen (1-6 mg/L), while shallow water fish need higher levels (4-15 mg/L). Microbes such as bacteria and fungi also require dissolved oxygen. These organisms use DO to decompose organic material at the bottom of a body of water. Microbial decomposition is an important contributor to nutrient recycling. However, if there is an excess of decaying organic material (from dying algae and other organisms), in a body of water with infrequent or no turnover (also known as stratification), the oxygen at lower water levels will get used up quicker [5].

The chemical oxygen demand (COD) level is also very important to evaluate the water quality with respect to presence of organic and inorganic pollutants. Higher COD levels mean a greater amount of oxidizable organic material in the sample, which will reduce dissolved oxygen (DO) levels. A reduction in DO can lead to anaerobic conditions, which is deleterious to higher aquatic life forms. The COD test is often used as an alternate to BOD due to shorter length of testing time [6].

Decomposition of manure, dead plants and animals by bacteria in the aquatic and terrestrial environments produce ammonia and other ammonium compounds through conversion of nitrogen during decomposition of tissues in a process called ammonification [7]. When ammonia is present in water at high enough levels, it is difficult for aquatic organisms to sufficiently excrete the toxicant, leading to toxic build up in internal tissues and blood, and potentially death. Environmental factors, such as pH and temperature, can affect ammonia toxicity to aquatic animals [8].

Changes in turbidity, sediment deposition, nutrient load and contaminant load will also affect benthic macroinvertebrates following increased freshwater input [9]. In this study the animals which are bigger than 2 mm that have been considered because if it is too small it is hard to see

[10]. Invertebrates can tell us a great deal about the "state of health" of our water bodies. The presence of many invertebrate species usually indicates clean water, cool temperatures and generally natural conditions. A stream which lacks any invertebrate life has a major habitat problem, possibly because of recent pollution, or low flow conditions [11]. Invertebrate wildlife is classified based on whether they live in water or can live in dirty water [12]. The main advantage of using macrobenthos is that some have life span of up to year and greater, they relatively sedentary, have varying sensitivities to changes in water quality and they are easily collected and identified [13].

Methodology

In order to ensure that this study goes perfectly, plans must be made more carefully. Background information on this study must first be understood based on the literature that has been done before. After all the background information were obtained in this study, the types of laboratory test were included in preparing the materials to be used. Water quality index (WQI) and biological water quality index (BWQI) was determined by using data collection and data analysis. The sample used to study the WQI characteristic was measured and included dissolved oxygen, conductivity, pH, temperature and turbidity, and macroinvertebrate as BWQI. The study was conducted at the upper region of Kelantan River basin which at District Kuala Krai as its impact from flood event. The study focused on four locations (Table 1) around Kuala Krai rivers, namely Sg. Manik Urai_1, Sg. Manik Urai_2, Sg. Durian and Sg. Geh. The study was conducted in 3 sampling each station are Sampling 1 (4 June 2015), Sampling 2 (7 August 2015) and Sampling 3 (3 October 2015).

Table 1: The geographical coordinates of sampling station

Station	Site	Longitude	Latitude
1	Sg. Manik Urai_1	5.33977°N	102.22663°E
2	Sg. Manik Urai_2	5.37105 °N	102.23122°E
3	Sg. Durian	5.56520°N	102.20151°E
4	Sg. Geh	5.62541°N	102.20260°E

Sampling and Data Collection

Macrobenthos Sampling. On Macrobenthos sampling, there was a considerable literature on respiration rates among benthos. Most published work falls into two basic categories such as benthic system respiration and respiration of selected benthic animal species. Macrobenthos samples will be collected using Surber Sampler (quadrate size $0.09m^2$). The Surber sampler is of limited utility in water over 30 cm deep. All the materials collected will be transferred to a plastic bottle and preserved with 70% of alcohol for laboratory analysis. At the laboratory, the materials in the plastic bottle will poured onto an enamel tray. The benthic animals were sorted and identified using the JVC KY-F70B microscope. The data were recorded and identified. The type of benthic animals was marked in table macrobenthos score calculation. The total average score was calculated and the classification was made based Biological Water Quality Index (BWQI) and the water quality was determined.

$$\text{Biological Water Quality Index (BWQI)} = \frac{\text{Score of Invertebrates}}{\text{Type of invertebrates}} \quad (1)$$

Water Quality Sampling. On Water Quality Sampling, In-situ parameter such as temperature, pH and DO were determined using Multi-Parameter Analyzer-Consort C535 and 55 YSI respectively. While the other parameters were analyzed at the laboratory by collecting water sample into 2 liter polyethylene bottle and the sample preserved with a few drop of nitric acid (HNO_3) and stored at 4^oC. BOD analyses were carried out as soon as possible in order to minimize biological activity in the water. All tests were carried out following APHA at all available water supply resources.

$$WQI = 0.22*(SI\ DO) + 0.19*(SI\ BOD_5) + 0.16*(SI\ COD) + 0.15*(SI\ AN) + 0.16*(SI\ SS) + 0.12*(SI\ pH) \quad (2)$$

where SI indicates the sub-index for each parameter.

Water Quality Analysis

Water quality analysis was performed on site and in laboratory studies. The analysis aims to determine the content of the six parameters of the Water Quality Index (WQI) of the river water.

In Situ Analysis. In-situ measurements of water quality parameters were carried out in the study site. Methods of measurement of in-situ tests conducted to determine the actual reading of the river without having to involve the taking of water samples. WQI parameters are analyzed on site were the water temperature, dissolved oxygen (DO) and the index of alkalinity or acidity (pH).

Laboratory Analysis. While the parameters analyzed in the laboratory were the Chemical Oxygen Demand (COD), ammonia nitrogen (NH_3N), Biochemical Oxygen Demand (BOD) and Suspended Solids (SS).During the analysis carried out, all six parameters either physically or chemically treated in accordance with the formula set forth by the Department of Environment and it varies between one parameter with one other parameter.

Identification of Macrobenthos

The procedure carried out were n accordance with the guidelines for flow analysis in invertebrates set by the Department of Environment. At first the little river filled plates were cleared. Then, nets soaked into the river up to the base to get a sample of living macrobenthos required (nets scoop in areas with dead leaves, lots of gravel and place a lot of plants and floating organisms in the water can also be identified. Net contents were poured into a tin plate and a rough note whether there was life on the plate movements resulted from the scoop. If there is movement in a tin plate, a spoon was used to take the life and store them in a plastic container. Benthic animal was identified with a magnifying glass and marked in table macrobenthos score calculation. The total average score was calculated and the classification was made based on Biological Water Quality Index (BWQI) and the water quality was determined.

Results and Discussions

This assessment was based on Water Quality Index (WQI) and BWQI for the river. The data were collected from the river based on the parameters chosen were dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solid (SS), ammonia-nitrogen (NH_3N) and pH that were collected along the rivers. Besides that, the analysis of the water quality using WQI and BWQI was conducted.

Water Quality Parameter

Table 2 shows the results of the DO analysis of the four rivers. The results showed that DO level dropped from Sampling 1 to Sampling 3. For example, the value on Sampling 1 for Sg. Manik Urai 1 was 9.15 mg/L and at Samping 3 was 7.25 mg/L. On Sampling 3, DO decreased but remained stable when at the day was raining, then the BOD decreased because the rivers may cause aerobic process while raining. DO levels decrease indicated the level of water quality has declined. If the level of DO decreases it may cause poor odor as a result of anaerobic degradation. DO conditions contrary to the BOD, the higher the BOD, the lower DO. It can be compared between Table 2 and Table 3. The DO increase was important than BOD. BOD was of more significant to food webs than to water quality. Oxygen plays an important role as indicators of water quality, because oxygen plays a role in the process of oxidation and reduction of organic and inorganic materials. BOD is the amount of oxygen required for microbial metabolism of organic compounds in water. DO depletion was most likely to become evident during the initial aquatic microbial population explosion in response to a large amount of organic material. If the microbial population deoxygenates the water, however, that lack of oxygen imposes a limit on population growth of aerobic aquatic microbial organisms resulting in a longer term food surplus and oxygen deficit [14].

Adequate DO was necessary for good water quality. Oxygen is a necessary element to all forms of life. Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. As dissolved oxygen levels in water drop below 5.0 mg/L, aquatic life is put under stress. The lower the concentration, the greater was the stress. Oxygen levels that remain below 1-2 mg/L for a few hours can result in large fish kills [15]. COD is a measure of water pollution by organic substances that naturally can be oxidized via microbial processes, and result in reduced oxygen dissolved in water. It can be seen in Table 2 and Table 4. Reading COD parameter is not uniform, where records show there was a pattern of significant fluctuations in each river.

Results on Table 5 show highest parameter suspended solids is 74.5 mg/L in Sg. Manik Urai 1 and the lowest is 3 mg/L in Sg. Geh on Sampling 3. During flood, strength and speed of flowing water erodes the banks of streams and contribute to contamination, particularly of silt and suspended solids organic substance. Meanwhile, based on Table 6, the highest ammonia nitrogen is 0.76 mg/L in Sg. Manik Urai 1 and the lowest is 0.22 mg/L in Sg. Geh on Sampling 3. Readings of this parameter were not uniform, where records showed there was a pattern of significant fluctuations in each river. Table 7 shows that pH value of each river was different from every other month. The lowest reading recorded by Sg. Durian was 6.70, while the highest recorded in Sg. Manik Urai 1 and Sg. Geh (6.83). This showed the overall average index alkalinity (pH) of water streams approaching 7.

Table 2: Average DO of Data Sampling

Rivers	Sampling 1	Sampling 2	Sampling 3
Sg. Manik Urai 1	9.15 ± 0.25	8.95 ± 0.45	7.25 ± 0.25
Sg. Manik Urai 2	9.15 ± 0.15	9.05 ± 0.05	7.05 ± 0.25
Sg. Durian	9.60 ± 0.10	9.40 ± 0.50	7.25 ± 0.35
Sg. Geh	9.15 ± 0.25	8.95 ± 0.45	7.25 ± 0.25

Table 3: Average BOD of Data Sampling

Rivers	Sampling 1	Sampling 2	Sampling 3
Sg. Manik Urai 1	5.5 ± 0.5	7.5 ± 3.5	3.0 ± 1.0
Sg. Manik Urai 2	6.5 ± 0.5	4.5 ± 3.5	3.5 ± 1.5
Sg. Durian	4.0 ± 1.0	11.0 ± 1.0	11.0 ± 1.0
Sg. Geh	15.0 ± 1.0	14.0 ± 0.0	13.0 ± 3.0

Table 4: Average COD of Data Sampling

Rivers	Sampling 1	Sampling 2	Sampling 3
Sg. Manik Urai 1	10.0 ± 0.0	11.0 ± 5.0	4.0 ± 2.0
Sg. Manik Urai 2	10.0 ± 1.0	8.5 ± 5.5	6.5 ± 3.5
Sg. Durian	6.5 ± 2.5	17.0 ± 0.0	16.0 ± 2.0
Sg. Geh	21.0 ± 1.0	23.0 ± 1.0	18.0 ± 2.0

Table 5: Average SS of Data Sampling

Rivers	Sampling 1	Sampling 2	Sampling 3
Sg. Manik Urai 1	75.0 ± 5.0	21.0 ± 1.0	74.5 ± 0.5
Sg. Manik Urai 2	30.0 ± 10.0	14.0 ± 6.0	67.0 ± 55.0
Sg. Durian	2.0 ± 1.0	28.0 ± 1.0	13.5 ± 0.5
Sg. Geh	7.0 ± 4.0	13.5 ± 2.5	3.0 ± 0.0

Table 6: Average AN of Data Sampling

Rivers	Sampling 1	Sampling 2	Sampling 3
Sg. Manik Urai 1	0.68 ± 0.03	0.34 ± 0.01	0.76 ± 0.06
Sg. Manik Urai 2	0.33 ± 0.08	0.27 ± 0.05	0.40 ± 0.24
Sg. Durian	0.12 ± 0.00	0.53 ± 0.02	0.44 ± 0.03
Sg. Geh	0.38 ± 0.08	0.42 ± 0.04	0.22 ± 0.08

Table 7: Average pH of Data Sampling

Rivers	Sampling 1	Sampling 2	Sampling 3
Sg. Manik Urai 1	6.72 ± 0.01	6.79 ± 0.00	6.83 ± 0.00
Sg. Manik Urai 2	6.74 ± 0.01	6.78 ± 0.00	6.82 ± 0.00
Sg. Durian	6.70 ± 0.00	6.78 ± 0.00	6.78 ± 0.01
Sg. Geh	6.72 ± 0.01	6.79 ± 0.00	6.83 ± 0.00

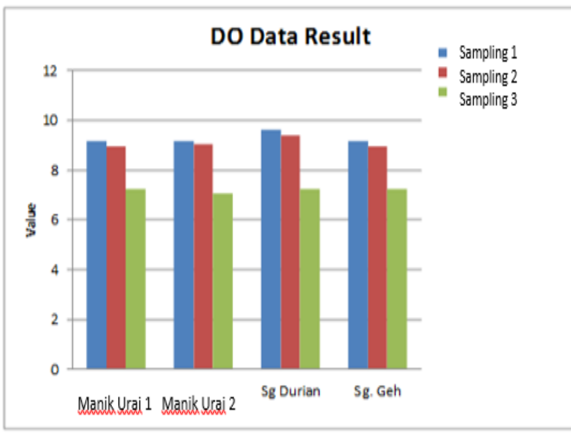

Figure 1: DO Graph Result

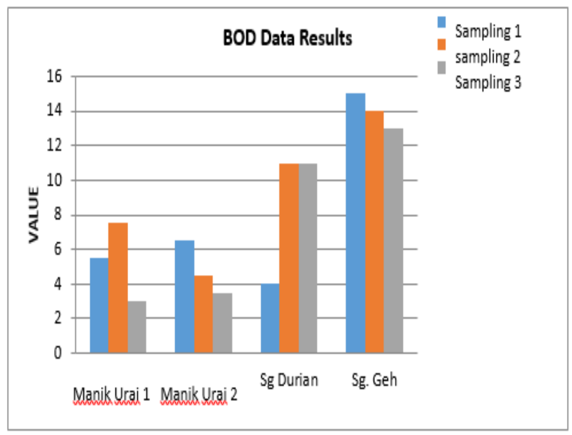

Figure 2: BOD Graph Result

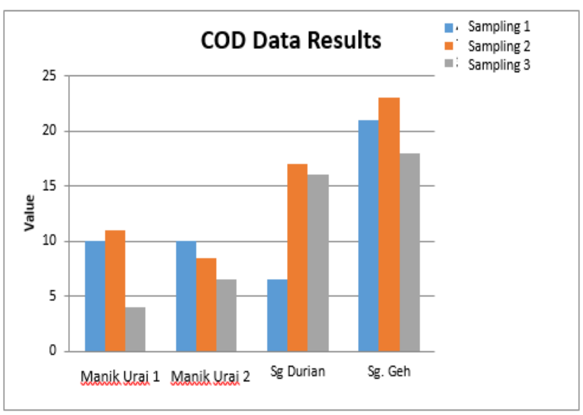

Figure 3: COD Graph Result

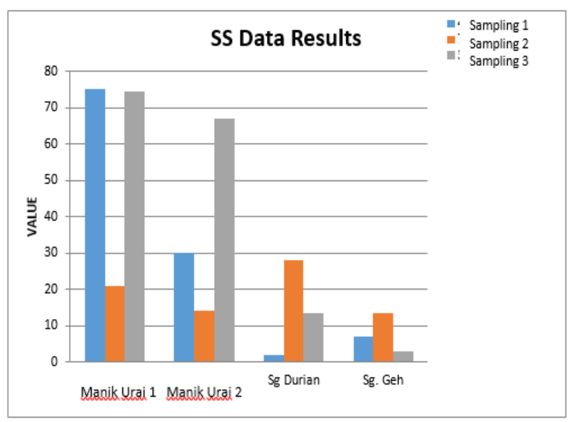

Figure 4: Suspended Solids Graph Result

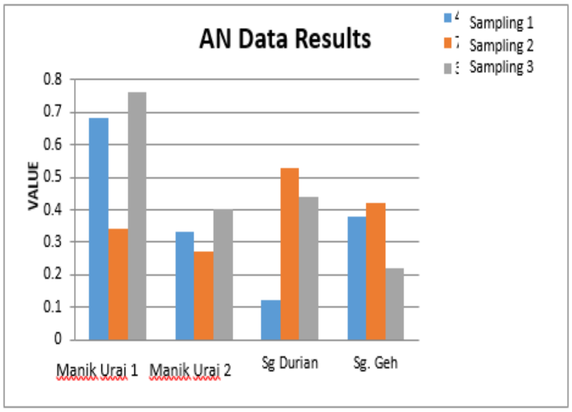

Figure 5: Ammonia-Nitrate Graph Result

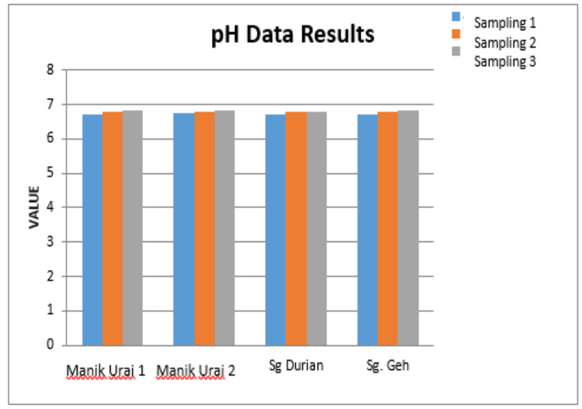

Figure 6: pH Graph Result

Water Quality Index Result

Based on Figure 7, the water quality index was at class II at every test except Sg. Durian in class I on 4 June 2015. The level of quality was not uniform where the river Sg. Manik Urai 1 and Sg. Manik Urai 2 on Sampling 2 has increased, then it decreased on Sampling 3, it because during sampling 3 it rained. While for Sg. Durian and Sg. Geh slightly increased level of quality. It can be seen from Sampling 2 to Sampling 3 in an increase in the slightest. This was due to the river located at rural area and low activities that can cause pollution.

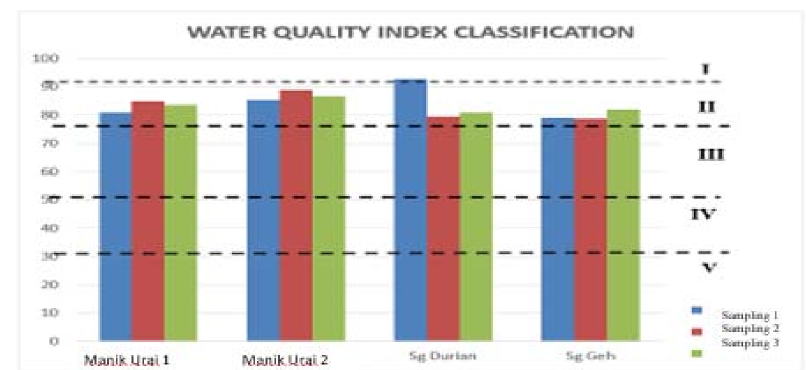

Figure 7: Water Quality Index Classification Graph Result

In addition, in Figure 7, the level of the water quality was the highest observed in Sg. Durian (92.74) on Sampling 1 and the lowest level is the Sg. Geh (78.69) on Sampling 2. This area was far from urban and town areas. All of the quality level of the river was in the average range clean and slightly polluted. The records showed there was a pattern of significant fluctuations in each river. This was because the water quality was too low are not suitable for living organisms and bacteria. Therefore, it can be said that the rivers water were still safe and not harmful to wildlife because of the relatively good water quality.

Water Quality Index Between Laboratory Analysis and DOE Major River

In Figure 8 it can be seen the level of major rivers such as the Sg. Lebir decreased from 2013 to 2015. In 2013 its level of class II (87), while in 2015 its level of class III (74.77). After months of floods in Kuala Krai, the study quality level of its river such as Sg. Lebir increased (class II) water quality compared to the quality of water for DOE 2015. Furthermore, based on Figure 7, the level of water quality classification of major rivers such as the Sg. Lebir decreased from 2013 to 2015. It can be seen in the year 2013 to be at this level clean but in 2015 it became slightly polluted. While after the flood occurred at Sg. Lebir, it changed to good and acceptable water quality.

In Table 8, the water quality index of major rivers such as Sg. Kelantan decreased from 2013 to 2015. It decreased slightly in 2013 which is in class II (85), and in 2015 was in class III (75.29). This was because at the end of December 2014 experienced a major flood.. The level of water quality index in rivers Sg. Kelantan was in class II on the study compared with DOE 2014 until 2015. It can also be seen in Table 8, where the level of classification of water quality in Sg. Kelantan decreased from 2013 to 2015. Besides that, the results on the study obtained were increased after a few months of flooding. This change was important for the life of the river.

Table 8: Comparison of Water Quality Index of Laboratory Analysis and DOE Major River Results

Major River	DOE (2013)	DOE (2014)	DOE (2015)	This Study
Sg. Lebir	87	82	75	85
	II	II	III	II
	C	C	SP	C
Sg. Kelantan	85	82	75	82
	II	II	III	II
	C	C	SP	C

*C – Clean, SP- Slightly Polluted

Macrobenthos - Percentage of Order Benthos

In Figure 8, the percentage of Odonata was higher about 34% on Sg. Manik Urai 1. Odonata is a life that most do not like high pollution levels. For Pleocoptera the percentage is second higher about 34%. It shows Sg. Manik Urai 1 in rather clean because it will be lost if the river is polluted. Ephemeroptera, Plecoptera and Tricoptera are often considered as good indicators of water quality [16] and can only survive in clean and oxygen-rich waters. For Sg. Manik Urai 2, the high percentage of Odonata was about 62%. The second higher at Sg Manik Urai 2 is Decapoda about 33%. It is the order of the types of shrimp living river where it is very sensitive to pollution [17].

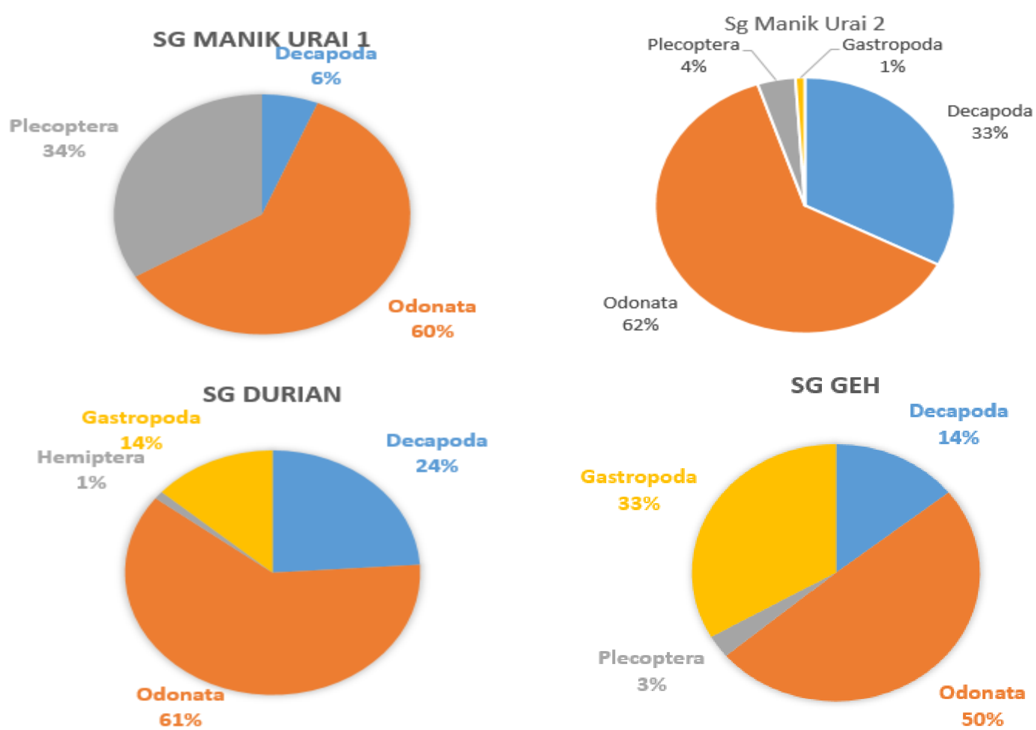

Figure 8: The Percentage of Order Benthos

For Figure 8, the percentage of Odonata is higher about 61% on Sg. Durian. This shows the level of contamination is less in this river. Besides that, on decapoda it shows second higher order at Sg.

Durian about 24% because low pollution in the river because of decapod very sensitive to pollution [17]. According to Figure 2.8 for Sg. Geh, the percentage of Odonata was 50% and the Gastropoda was 33%. This shows the increasing level of water quality because it will not appear if there were higher levels of pollution.

Water Quality Index Based On Biological Indicator

Biological indicator is another way to determine the quality of a water body. The amount of macro organism and micro organism in river can be used to determine the quality of the river. The analysis of the biological indicator is an easy method and can be done by all as it does not use any tools. The analysis can be done just by collecting a certain amount of water and calculate the amount of macro-organism present in the water. The amount and types of the macro-organism can be use to determine the quality of a water body or river.

Table 9: Water Quality status based on BWQI of the four rivers (Sampling 1)

Components	Sg. Manik Urai 1	Sg. Manik Urai 2	Sg. Durian	Sg. Geh
Total Score	36	19	28	16
No. of Animal Type	5	3	5	3
Index	7.2	6.3	5.6	5.3
Class	II - Clean	II - Clean	II - Clean	II - Clean

Table 10: Water Quality status based on BWQI of the four rivers (Sampling 2)

Components	Sg. Manik Urai 1	Sg. Manik Urai 2	Sg. Durian	Sg. Geh
Total Score	34	32	31	19
No. of Animal Type	5	5	7	4
Index	6.8	6.4	4.4	4.8
Class	II - Clean	II - Clean	III - Average	III - Average

Table 11: Water Quality status based on BWQI of the four rivers (Sampling 3)

Components	Sg. Manik Urai 1	Sg. Manik Urai 2	Sg. Durian	Sg. Geh
Total Score	32	26	28	47
No. of Animal Type	5	4	5	9
Index	6.4	6.5	5.6	5.2
Class	II - Clean	II - Clean	II - Clean	II - Clean

Figure 9 showed a graph of biological water quality index for Sg. Manik Urai 1 decreased from Sampling 1 to Sampling 3. It may be assessed microbenthos life experienced a high level of sensitivity to changes in water quality and river conditions that occur after the flood. While for Sg. ManikUrai 2 it slightly increased level of biological water quality index of Sampling 1 to Sampling 3. This increase can be seen where there was a change in circumstances that caused flooding river water quality has changed in terms of the pollution, nutrient levels and so on [18].

Sg. Durian stage for biological water quality index experienced quality conditions fluctuate. Where on Sampling 2 it decreased, while on Sampling 3 it upward. This may be assessed as at Sampling 2 there were quality conditions of the river unsuitable for life microbenthos due to weather factors, the rate of water quality and so on. For Sg. Geh, it decreased slightly in Sampling 2 but it increase slightly upward again on Sampling 3. This was because on Sampling 2 the weather was warm but on Sampling 3 was wet. This condition may occur due to weather conditions and factors for life microbenthos to adapt to new environmental conditions. The temperature of surface waters was influenced by latitude, altitude, season, time of day, air circulation, cloud cover and the flow and depth of the water body. In turn, temperature affects physical, chemical and biological processes in water bodies and, therefore, the concentration of many variables. As water temperature increases, the rate of chemical reactions generally increases together with the evaporation and volatilization of substances from the water. The metabolic rate of aquatic organisms was also related to temperature, and in warm waters, respiration rates increased leading to increased oxygen consumption and increased decomposition of organic matter [19].

Figure 9: The Graph of Biological Water Quality Results

Water Quality Status Based On Biological Water Quality Index

In Figure 2.10, it can be seen the average biological water quality index was in class II (rather clean). It showed all the rivers were safe and in clean condition. Macrobenthos were very sensitive to changes in the environment and the river.

Table 12: Water Quality status based on BWQI of the four rivers

Components	Sg. Manik Urai 1	Sg. Manik Urai 2	Sg. Durian	Sg. Geh
Index	6.8 ± 0.4	6.4 ± 0.1	5.2 ± 0.4	5.1 ± 0.20
Class	II - Clean	II - Clean	II - Clean	II - Clean

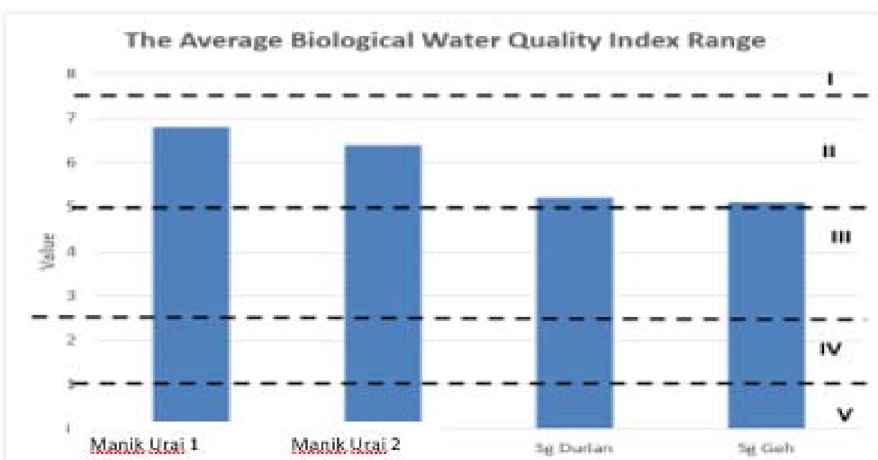

Figure 10: The Average Biological Water Quality Index Range For 4 Rivers

Comparison between WQI and BWQI

From Table 13, the study of which can be viewed using laboratory analysis and biological indicator gave almost the same results. It can be seen that the result of the classification of all rivers are in class II for both types of tests. This study showed that using both methods correctly can provide almost the same results. It also showed the level of the Water Quality Index will affect the Biological Water Quality Index because it is very sensitive to any change and pollution.

Table 13: The Comparison Water Quality status based on WQI and BWQI

River	Laboratory Analysis			Biological Indicator		
	WQI	Class	WQ Status	BWQI	Class	BWQ Status
Sg. Manik Urai 1	83.2 ± 2.0	II	C	6.8 ± 0.4	II	Clean
Sg. Manik Urai 2	87.0 ± 1.5	II	C	6.4 ± 0.1	II	Clean
Sg. Durian	84.4 ± 5.9	II	C	5.2 ± 0.4	II	Clean
Sg. Geh	79.9 ± 1.5	II	SP	5.1 ± 0.2	II	Clean

Conclusions

Big floods which occurred in December 2014 gave a positive and negative impact on water quality and biological life in each river. The negative effect was a decrease in water quality index level but for a positive impact on the level of biological water quality index has increased. Based on a study conducted in rivers close by Kuala Krai, Kelantan, the average level of water quality index was in class II but Sg. Geh decreased to Slightly Polluted. The average water quality index and an average of Biological Water Quality Index (BWQI) improved to class II. This showed through biological research directly impact on aquatic life, especially as macrobenthic life. Life macrobenthic affected more sensitive than the study through water quality index, but to determine the accuracy of the amount of contaminants study of water through certain parameters and measurement through water quality index (WQI) should be done. It can be seen in 2013 and 2014 index of water quality data for the major rivers are categorized as class II (clean). This situation was due to the location in the area of low population density and rural areas. While in terms of activities it was focused on agricultural and land use activities. However, regular surveillance and supervision by the local authorities in relation to sustainable land use activities that can be implemented to ensure the quality of the environment at a good level. In addition, the water quality also decreased after the occurrence of major floods at the end of December 2014 and then it increased after months later. Therefore, awareness of society on environmental protection should be emphasized especially in the aftermath of this flood.

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