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Benthic Macroinvertebrates Composition and Distribution at Sungai Dawai and Sungai Dekong in Lojing Highland, Gua Musang, Kelantan

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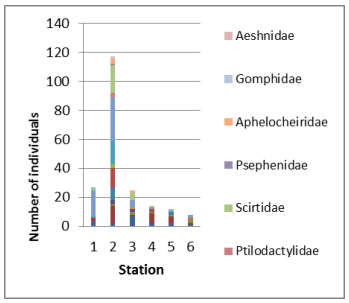
Graphical abstract



Abstract

A preliminary study of benthic macroinvertebrate at two rivers in Lojing Highlands, Kelantan was conducted in January 2014 to study and describe the composition and distribution at upland area. Benthic macroinvertebrate samples were collected by using Surber net (0.3m X 0.3m) at six sites around Sungai Dawai and three sites at lower part of Sungai Dekong. A total of 182 individuals of phyla arthropoda with six orders namely Ephemeroptera, Plecoptera, Trichoptera, Ordonata, Coleoptera and Hemiptera were found at Sungai Dawai. For station 4 which was located at Sungai Dawai, 14 families of benthic macroinvertebrate was found such as Scirtidae, Elmidae, Heptageniidae, Perlidae, Chironomidae, Simuliidae, Baetidae, Tipulidae, Emphididae, Ptilodactylidae, Psephenidae, Aphelocheiridae, Gomphidae and Aeshnidae. Reduction in richness, diversity and evenness was observed from Sungai Dawai to Sungai Dekong due to the changes of water condition and their habitat, such as canopy cover by logging and agricultural activities. The change distribution of benthic macroinvertebrates was useful to detect the impacted sites and the river health quality consequence.

Keywords: Benthic macroinvertebrates; arthropoda; composition; distribution; richness and diversity

1.0 INTRODUCTION

Benthic macroinvertebrates, also known as benthos, are referred as organisms which are invertebrates that can be seen by naked eyes and stay at the bottom part of the water body [1]. Benthic macroinvertebrates are generally retained by mesh sizes of 0.05m, relatively long-lived, expose to aquatic ecosystem change and spend most of their life in water body. Accordingly, they can be in any groups such as athropoda, insecta, molusca, anellida, oligochaeta and arachinds. They are one of the food sources for some other organism like fish, small mammals and birds [2, 3]. Some of them are also involved in circulation and recirculation of nutrients in aquatic environment [2, 3]. However, their distribution and composition depend on physico-chemical of water and also habitat condition as they have different levels of tolerance to any pollution or change in aquatic ecosystem. Therefore, a lot of researchers and associations used them as indicators to represent the condition of water in aquatic system.

Most of the benthos found at lotic freshwater area was insect larvae such as Ephemeroptera, Plecoptera, Trichoptera, Ordonata, Coleopteran and Diptera [4, 5]. Nowadays, benthos is one of the components that can be used as biological indicator for biological assessment for river health due to their effectiveness based on cost, time and easy methodology. For example, some insect larvae such as Ephemeroptera, Plecoptera and Trichoptera (EPT) were used as biological indicator to represent the fast flowing river health condition. This was a cause of development a biotic index based on these organisms which is known as the EPT index [6]. However, there is also another biotic index that gives score based on the level of tolerance for benthos organisms such as Biological Monitoring Working Party (BMWP) and Family Biotic Index (FBI) [4]. Biotic index based on benthos was further developed and derived from time to time due to the awareness on the importance of benthic macroinvertebrates in representing the river health [7].

Lojing Highland is one of the areas for recreational activity and ecotourism which needs a sustainable river that will lead to sustainable ecotourism. Unfortunately, human activities such as excessive recreational and logging activities as well as agricultural exploitation in the area cause some changes in the river ecosystem [4].Thus, river health assessment and monitoring need to be done. Benthic macroinvertebrates distribution and composition can be used as one of the components to assess the river health to help authorities in decision making to sustain the

river at Lojing Highland. Thus, this preliminary study on composition and distribution of benthic macroinvertebrates at two rivers at Lojing Highland was conducted to help in contributing database for further research as well as assessment and monitoring of the river in the area.

2.0 METHODOLOGY

2.1 Study area

The study areas were located at fast-flowing river located within the Lojing Highland which is Sungai Dawai located at N 04 38' 02.8" E 101 30' 16.3" and Sungai Dekong N 04 38' 02.8" E 101 30' 16.3" (Figure 1). Lojing Highland was a part of Gua Musang district and is located in the south-west of Kelantan with altitude from 610-1500m above sea level. Nine sampling stations were identified using Global Positioning System (GPS). Six stations were located within Sungai Dawai and another three stations were located within downstream of Sungai Dekong. Station 4 was the last point for Sungai Dawai before it merges with Sungai Dekong.

2.2 Benthic Macroinvertebrates Sampling

Benthic macroinvertebrates sampling was conducted the aforementioned stations by using Surber Net with 500 micron mesh size combined with a rectangular quadrate with the size of 30cmx30cm (0.09 m^2). Benthic macroinvertebrates will be collected three times at each station. All three samples in each sampling station were composited as one sample. Eighty percent ethanol was used to preserve the benthic macro invertebrate samples before sending to laboratory for identification.

2.3 Benthic Macroinvertebrates Analyses

The benthic macroinvertebrates samples were rinsed with tap water to remove the preservative before it can be sorted out in to major taxa. Samples that have been sorted were stored in 10 ml glass bottle containing 70% ethanol for preservation. The identification of this sample was only up to the family level.

2.4 Data Analysis

Composition, richness, diversity and evenness will be measure with ecological indices such as Margalef's index (d), Shannon-weiner index (H) and Evenness (E). On other hand, biotic index such as ASPT, BMWP, EPT index also calculated to help in classifying the river health (Table 1) [3, 4, 5, 6, 8].

3.0 RESULTS AND DISCUSSION

Samples collected from all stations (Table 2) shows the total of 233 individuals which consists of twenty taxa (family) belonging to 7 orders of insecta (Ephemeroptera, Plecoptera, Trichoptera, Dipteral, Coleopteran, Hemiptera and Ordanata). Station 5 accounted for the highest abundance (50.21%) with seventeen families such as Perlidae, Baetidae, Heptageniidae, Hydropsychidae, Philopotamidae, Tipulidae, Simuliidae, Athericidae, Chironomidae, Elmidae, Ptilodactylidae, Scirtidae, Psephenidae, Aphelocheiridae, Gomphidae and Aeshnidae. The lowest abundance and taxa numbers were accounted at Station 3 with 0.86% and a family of diptera (Chironomidae) respectively. All the stations were dominated by insects, represented mostly by Coleoptera (24.8%) followed by the Chironomidae (18.03%) and Baetidae (12.02%). Elmidae and Scirtidae was more in abundance at Sungai Dawai then Sungai Dekong as only an individual of Elmidae was collected at Station 2 which was located at Sungai Dekong. Figure 2 shows the dominant taxa found at Sungai Dekong (Stations 1, 2 and 3) was Chironomidae. Figure 3 shows the diversity of benthic macroinvertebrates collected in Sungai Dawai.

Compositions and distributions of benthos depend on several factors such as water quality, food availability, feeding behaviour, habitat characteristics and composition of substrate. The alteration on river ecosystem will influence the composition and distribution of benthos as evident by less richness of benthos found in the large size of a lotic area [9]. This is due to the changes in substrate composition, canopy percentage and food availability which can influence the benthos composition. On other hand, human activities such as agricultural, ecotourism and logging also change the quality of water and alter the substrate composition which also leads to changes in benthos composition. This study showed differences in composition between Sungai Dawai and Sungai Dekong. The composition of benthos decreased from Sungai Dawai to the middle part of Sungai Dekong. This phenomenon indicates that Sungai Dawai is cleaner than Sungai Dekong.

Table 3 shows the taxonomic richness, composition, diversity and tolerance index for benthic macroinvertebrates at both rivers with several indices. The Biological Monitoring Working Party (BMWP) score for Sungai Dekong is less than 10, which indicates the river was polluted and very poor condition as compared to Sungai Dawai (BMWP score of more than 41). This was support by EPT index as no EPT taxa found at Sungai Dekong. In contrast, EPT index result shows the water quality of Sungai Dawai was moderate as two families of ephemeroptera, a family of plecoptera and two families for trichoptera were found in this river. As known, EPT is very sensitive organisms and cannot survive in polluted water. Besides that, EPT species was found at a pebble substrate area instead of fine sediment. Based on our observation on the substrate, fine sediments were deposited over the pebbles area. It is believed that this happened due to the clearance of surrounding forest for logging and agricultural purpose. Thus, there was more Chironomidae family found at Sungai Dekong. Wahizatul *et al.* cited that Chironomidae was usually found at muddy, sandy area with fine sediment particles and can survive in any habitat as they has variety of feeding types [9]. In addition, the Average Score per Taxon (ASPT) score for all stations at Sungai Dawai was more than 6 except for Station 5 (5.3) which indicates that the river was of very good condition and unpolluted. Similarly, the Family Biotic Index (FBI) results show the river quality at Sungai Dawai was excellent with values between 0.00 and 3.75.

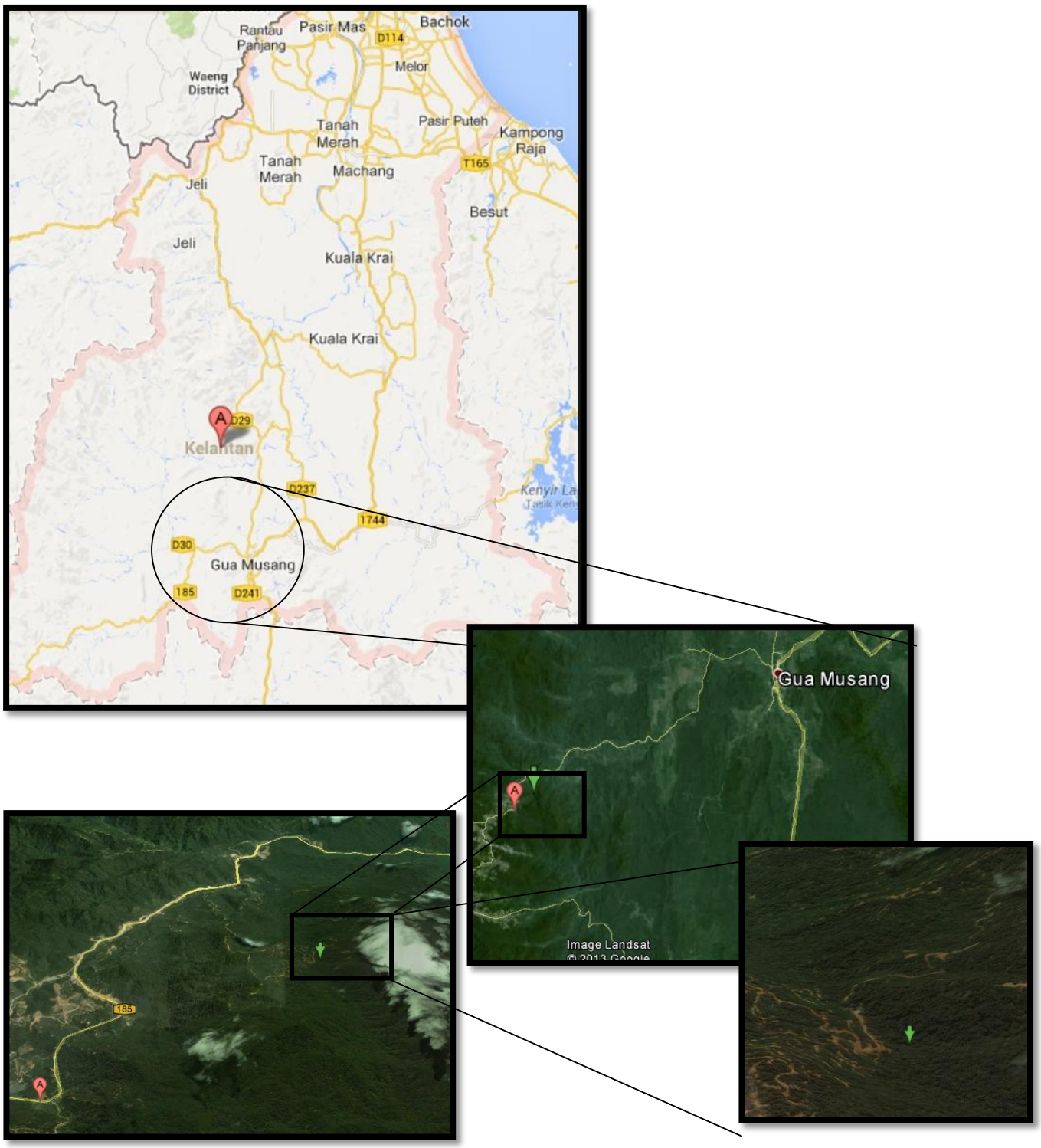


Figure 1 Map of the study area

Table 1 Biological indices used to analyze the data

No.	Biolgical indices	Description	Formula
	Margalef's index (d)	Used to calculate the richness of taxa. The higher index shows the greater diversity.	D = (S-1) /In N S = number of taxa N = total number of individuals
	Shannon-Weiner index (H)	Commonly used to calculate aquatic and terrestrial biodiversity.	$H = -\sum_{i=1}^{s}(p_i)(\log_2 p_i)$ p_i = number of individuals in a taxon s = number of taxa in the community
	Evenness (E)	Used to standardize abundance. It was range from 0-1. 0 is for few species present and close to 1 shows the species was equally abundant.	E = H'/In S H' = Shanon weiner Index S = number of species
	Family Biotc Index (FBI)	Providing tolerance values which ranges from very intolerant to highly tolerant (score from 0 to 10)	$FBI = \sum [(x_i)(t_i)/ n]$ x_i= number of individuals in taxon i^{th} t_i= tolerance value of ith taxon n= total number of organisms in the sample.
	Average Score per Taxon (ASPT)	Shows the average tolerance score of all taxa within the community.	Total score / number of families represent in sample
	Biological Monitoring Working Party (BMWP)	Score of tolerance level. The Higher score indicates less pollution.	Total score of individuals
	EPT index	Shows the taxa richness within insect group which are considered to be sensitive to pollution. Increase in good water quality	Total number of families represented by three orders of Ephemeroptera, Plecoptera and Trichoptera (EPT).

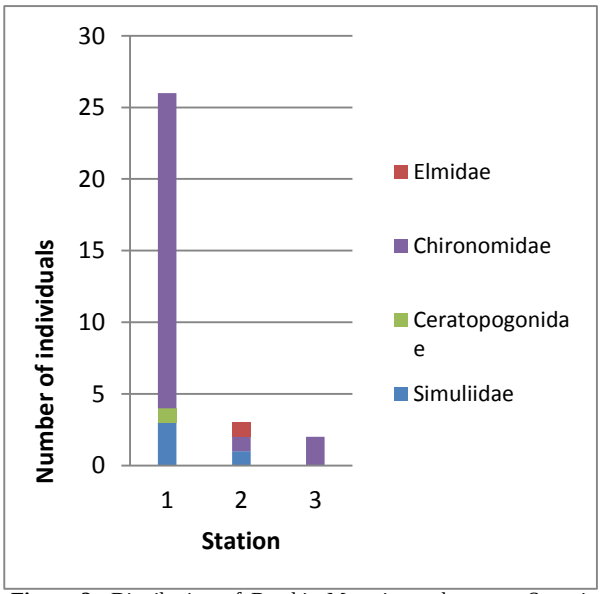


Figure 2 Distribution of Benthic Macroinvertebrates at Sungai Dekong

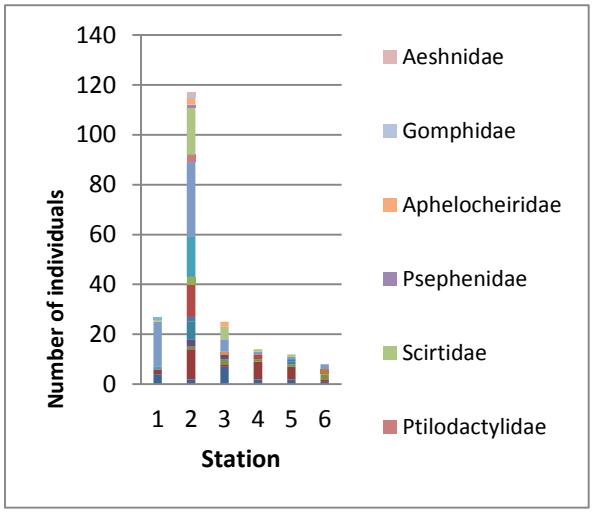


Figure 3 Distribution of Benthic Macroinvertebrates at Sungai Dawai

4.0 CONCLUSION

Generally, the water quality of Sungai Dekong was considered more polluted than Sungai Dawai as showed by the diversity, abundance and biological indices of benthic macroinvertebrates. EPT index and EPT ratio to total at Sungai Dawai were also higher than Sungai Dekong. The highest diversity and richness was at the end of Sungai Dawai (ST5) and the lowest was at Sungai Dekong (ST1). Twenty five percent of the benthic macroinvertebrates was Elmidae which was in abundance at Station 5, followed by Chironomidae (18%) which was in abundance at Station 1 (Sungai Dekong) and Station 5 (Sungai Dawai). A further study on benthic macroinvertebrates at Sungai Dawai and Sungai Dekong was recommended as there are many river tributaries connected to Sungai Dekong which are believed to be the pollution source to Sungai Dekong. Thus, more data was needed to help the authority to restore, monitor and sustain the surrounding area before being getting fully exploited and polluted.

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Table 2 Distribution and composition of benthic macroinvertebrates at Sungai Dekong and Sungai Dawai, Lojing Highland,Gua Musang, Kelantan

Parameter	Phyla	Class	Order	Family	Stations									Total **(individual)**	Percentage (%)
					Sungai Dekong			**Sungai Dawai**							
					ST1	**ST2**	**ST3**	**ST4**	**ST5**	**ST6**	**ST7**	**ST8**	**ST9**		
Distribution	**Insecta**	**Athropoda**	**Plecoptera**	**Perlidae**	0	0	0	4	2	7	2	2	1	**18**	**8**
			Ephemeroptera	**Baetidae**	0	0	0	2	12	1	7	5	1	**28**	**12**
				Heptageniidae	0	0	0	0	1	2	1	1	2	**7**	**3**
			Tricoptera	**Hydropsychidae**	0	0	0	0	3	2	0	0	0	**5**	**2**
				Philopotamidae	0	0	0	0	7	0	0	1	0	**8**	**3**
			Diptera	**Tipulidae**	0	0	0	0	0	0	0	0	2	**2**	**1**
				Tipulidae	0	0	0	0	2	0	0	1	0	**3**	**1**
				Simuliidae	0	1	3	0	13	0	2	0	0	**19**	**8**
				Athericidae	0	0	0	0	3	0	0	0	0	**3**	**1**
				Ceratopogonidae	0	0	1	0	0	0	0	0	0	**1**	**0**
				Chironomidae	2	1	22	1	16	0	0	0	0	**42**	**18**
				Empididae	0	0	0	0	0	1	0	0	0	**1**	**0**
			Coleoptera	**Elmidae**	0	1	0	18	30	5	1	1	2	**58**	**25**
				Ptilodactylidae	0	0	0	0	3	0	0	0	0	**3**	**1**
				Scirtidae	0	0	0	1	19	5	1	1	0	**27**	**12**
				Psephenidae	0	0	0	0	1	0	0	0	0	**1**	**0**
			Hemiptera	**Aphelocheiridae**	0	0	0	0	3	2	0	0	0	**5**	**2**
			Odonata	**Gomphidae**	0	0	0	0	1	0	0	0	0	**1**	**0**
				Aeshnidae	0	0	0	0	1	0	0	0	0	**1**	**0**
Total **(individual)**					**2**	**3**	**26**	**26**	**117**	**25**	**14**	**12**	**8**	**233**	**-**
Percentage Abundance **(%)**					**1**	**1**	**11**	**11**	**50**	**11**	**6**	**5**	**3**	**-**	
Number of Taxa					**1**	**3**	**3**	**4**	**16**	**8**	**6**	**7**	**5**	**53**	

Table 3 Taxonomic richness, composition, diversity and tolerance index for benthic macroinvertebrate at Sungai Dawai and Sungai Dekong, Lojing Highland, Kelantan

Stations	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9
Abundance (individual)	2	3	26	26	117	25	14	12	8
Abundance (%)	1%	1%	11%	11%	50%	11%	6%	5%	3%
Number of taxa	1	3	3	4	16	8	6	7	5
Shanon-Weiner Diversity Index (H)	-1.0	4.8	8.1	85.3	16.3	12.0	26.7	18.0	18.2
Margalef's Richness Index (D)	0.0	0.7	0.1	0.1	0.2	0.5	0.3	0.4	0.6
Evenness (J)	1.4	4.3	2.5	26.2	3.4	3.7	10.1	7.3	8.7
Biological Monitoring Working Party (BMWP)	2.0	12.0	7.0	26.0	84.0	49.0	39.0	46.0	34.0
Average Score Per Taxon (ASPT)	2.0	4.0	2.3	6.5	5.3	6.1	6.5	6.6	6.8
Citizen Monitoring Biotic Index (CMBI)	2.0	2.3	2.0	3.1	2.7	3.2	3.0	3.1	2.9
Family Biotic Index (FBI)	6.0	5.3	6.0	4.3	3.7	3.4	3.1	3.9	3.2
Ephemeroptera,Plecoptera and Trichoptera (EPT) INDEX	0.0	0.0	0.0	2.0	5.0	4.0	3.0	4.0	3.0
EPT:Total Ratio (%)	0%	0%	0%	23%	21%	48%	71%	75%	50%