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## Comparative analysis of Biotic Indices in water quality assessment: Case study at Sg. Bantang, Johor

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# Comparative analysis of Biotic Indices in water quality assessment: Case study at Sg. Bantang, Johor

**Mohammad Zulhusni Zakaria, Maryati Mohamed**

Center of Research for Sustainable Uses of Natural Resources, Faculty of Science,  
Technology and Human Development, Universiti Tun Hussein Onn Malaysia  
(UTHM). UTHM Campus Pagoh, 84600 Muar, Johor, Malaysia.

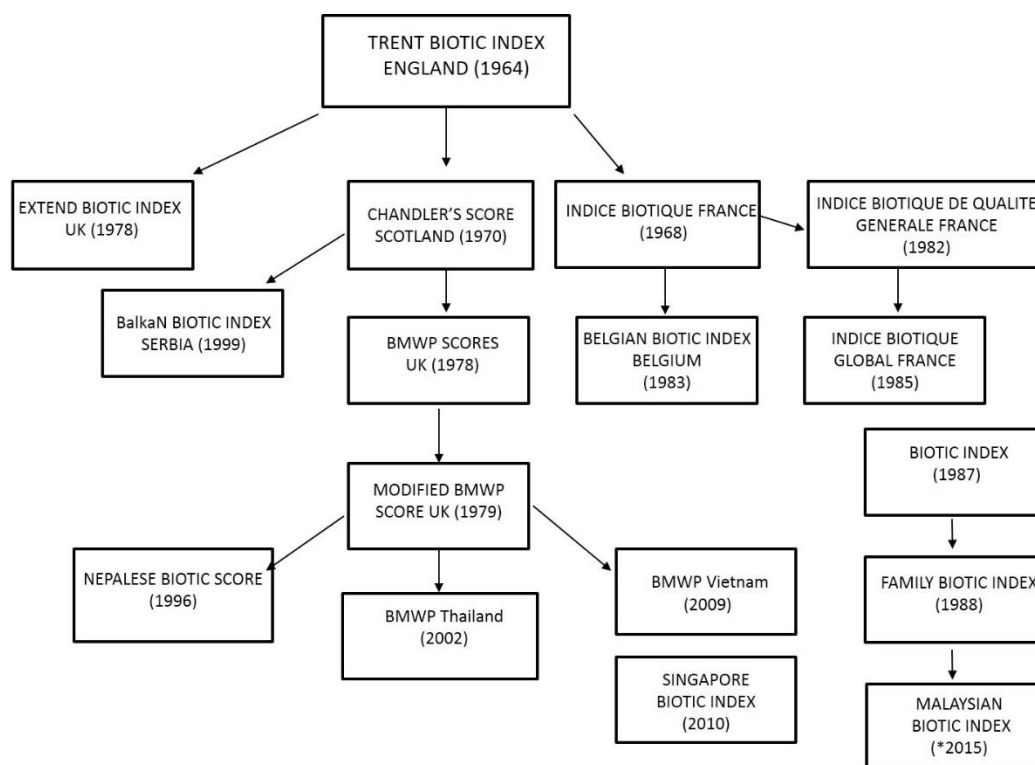
Email: maryati@uthm.edu.my

**Abstract.** Biotic indices are very useful tools as a rapid water assessment since freshwater had become a global issues for a decade but most of biotic indices developed are based on data from Europe or North American region. Geographically, there might be different in term of composition of macroinvertebrates in tropical region. Moreover, lacking in information regarding the effectiveness techniques which limited the use of biological monitoring in developing countries. Study were conducted to compared between biotic indices that originate developed based on macroinvertebrate data from United Kingdom which is Biological Monitoring Working Party (BMWP)) and several biotic indices which developed in tropical region which were BMWP-Thai, SingScore and BMWP-My. The purpose of this study is to know which index best reflects health of freshwater ecosystem in Malaysia. All indices were calculated based on data from Hutan Lipur Sungai Bantang (HLSB). HLSB ecosystem were provided a good physical and chemical variable which their water quality is ranging from moderately- good to excellent based on the composition of aquatic insects and water quality index (WQI). Despite of rapid development happened in Johor, we found 45 families of aquatic insects and half of them are clean water species and very useful in biological monitoring. From the result, BMWP-My was the most suitable biotic index to use in Malaysia water body since its give better reflect on the health of the river system. Finally, the uses of aquatic as biological monitoring tools were recommended because aquatic insects found almost in every freshwater habitat, their diversity and their sensitivity to environmental changes which make them a good biological indicator.

## 1. Introduction

Nowadays, water sources are very limited due to pollution causes by human activities such as aquaculture, agriculture, sand mining, ammonia pollution and many more. Rapid water assessment becomes crucial to determining the health of freshwater ecosystem. As alternative ways, several of biotic indices were introduced since long time ago with the first developed in 1964 was Trent Biotic Index originally from England and from that we can see many more indices were developed. Most of the biotic indices were developed based on countries necessity such as BalKaN Biotic Index in Serbia (1999), Chandler's Score in Scotland (1970), Indice Biotique France in France (1968), Belgian Biotic Index in Belgium (1983). In Asian countries, we have a Nepalese Biotic Index in Nepal (1996), BMWP-Thai in Thailand (2002), BMWP-Viet (2009), Singapore Biotic Index (2010) and the latest one is Malaysia Biotic Index in Malaysia (\*2015).





**Figure 1.** Evolution of the development of biotic indices all over the world [11,20]

In fact, there were several reasons why macroinvertebrates are reliable in assessing water quality which (1) macroinvertebrates were sensitive organisms that react quickly if any pollutant sign presence, (2) macroinvertebrates can be found any water bodies type, abundant and easy to collect by using aquatic net, (3) macroinvertebrates also have restricted movement, meaning that if any claim or poor water group species were found at a place it could represent the current condition, (4) their life span just enough to record environmental quality, (5) last but not least, macroinvertebrate communities are heterogenous, which varied in pollutant tolerancy [11].

Basically, there two methods in monitoring water quality which by using biological parameter and Physio chemical parameter. Since, an efficient assessment of water quality is critically needed for managing water sources [4] and because of that biological parameters were preferred over physiochemical parameter. Physical and chemical could detect pollutant directly, they only reflects water quality during sampling [11,8] as well as analysing them is more time consuming and costly because there are many expensive chemicals involved. In contrast, using of biological parameters were directly reflected the environment because they continue to expose them [5] and as mention in many literatures, they are various in the group which some of them are very sensitive towards pollution and some of them can tolerate very well in bad water condition due to that reason it could be useful as a good indicator to environment quality [4,7,1].

In this study, we were focusing on comparative analyse of biotic indices to determine which biotic indices have better reflected on health of the ecosystem based on data of aquatic insects in Malaysia. For that matter, several biotic indices were used which Biological Monitoring Working Party (BMWP), BMWP-Thai, SingScore, and BMWP-My.

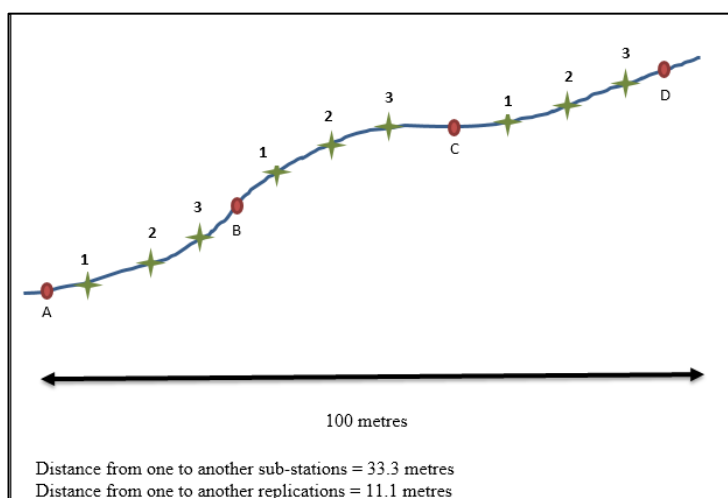
## 2. Methodology

### 2.1 Sampling site

This research was conducted at Hutan Lipur Sungai Bantang (HLSB) a recreational forest located in central Johor deep inside forested area 'Rezab Hutan Simpan Kekal Labis' (Figure 2). Sampling work was conducted three times from January 2017, May 2017 and July 2017 (Table 1). Overall, there are three sampling stations and for each station there are three collecting point. Sampling time for each collecting point was within five minutes and within those time, all the rock surfaces in swift-flowing water were rubbed to remove aquatic insects into the net. Each sampling station measures 100 meters (Figure 3).

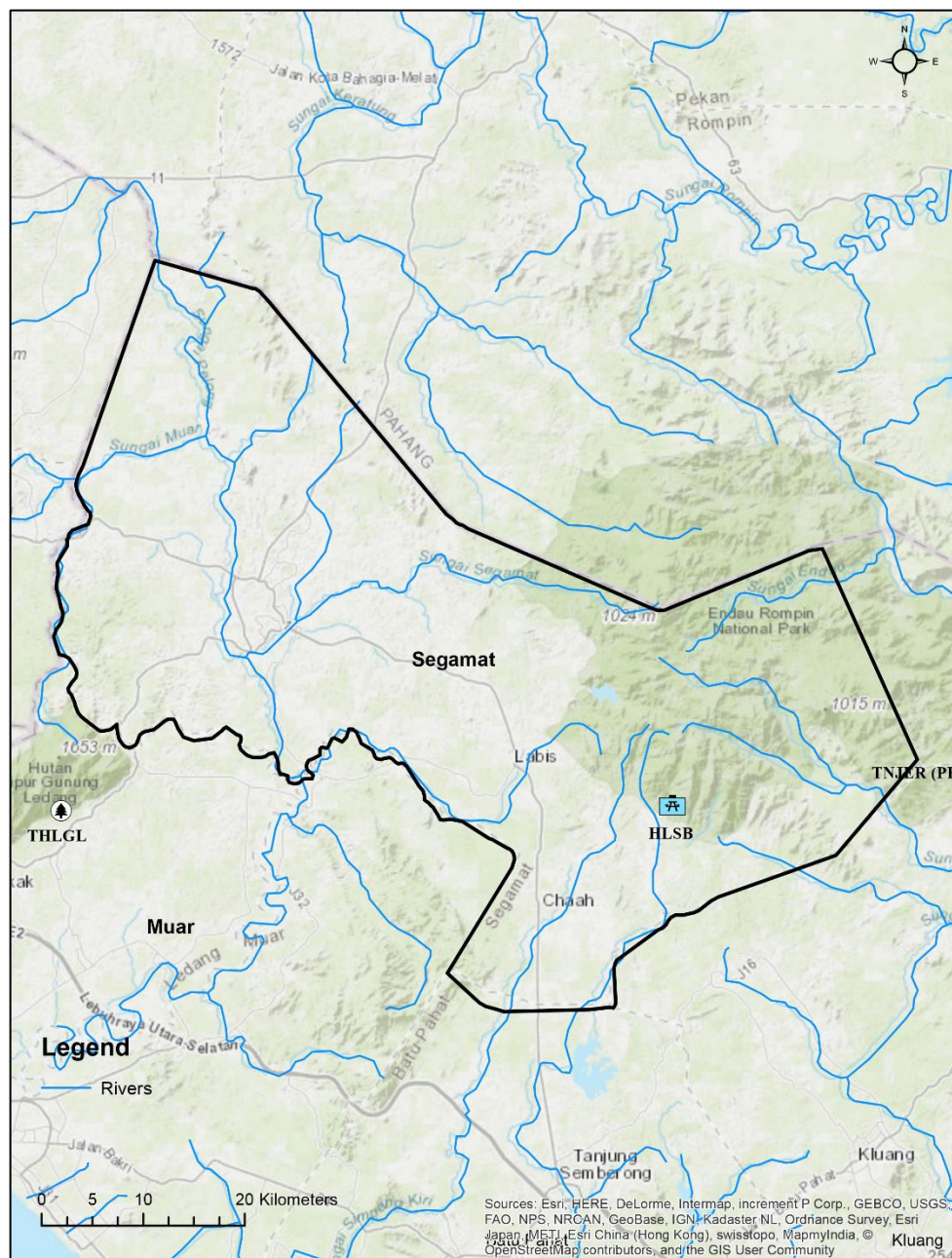


**Figure 2.** Sampling site condition at Hutan Lipur Sungai Bantang (HLSB)



**Figure 3.** Illustration of sampling method for aquatic insects specimen collections.





**Figure 4.** Map of sampling site

**Table 1.** Sampling work time frame

Replication	Date
1 <sup>st</sup> replicate	2-4 Jan 2017
2 <sup>nd</sup> replicate	13-15 May 2017
3 <sup>rd</sup> replicate	10-13 July 2017

## 2.2. Sample collection

Specimens were collected by using kicking technique with an aquatic net (size 18 inch X 9 inch with mesh size 900  $\mu\text{m}$ ). Specimens were sorted directly on the field into aluminum cap glass vials with contained 70% ethanol and brought back to the laboratory for identification purposed. Specimens were identified up to family level by using taxonomic keys from book 'Freshwater Invertebrates of the Malaysia Region' by [3] and preserved in 70% ethanol for further research purposes. All of specimens stored as a reference collection at Repository of the Centre of Research for Sustainable Uses of Natural Resources, Faculty of Applied Science and Technology, Universiti Tun Hussein Onn Malaysia.

## 2.3. Biotic indices

Four biotic indices were chosen for the analyses, based on their potential use in monitoring in Malaysia region. The biotic indices were: 1) Biological Monitoring Work Party Scoring System (BMWP) [14]; 2) BMWP-Thailand [15]; 3) SingScore [17] and BMWP-Malaysia [20]. BMWP was developed based on data in U.K [14] and its working by giving a scoring to benthic organisms based on their toleration toward water condition. The score or called as tolerance value would be ranging from 1 to 10 which 10 indicated very least tolerance and 1 indicated with the high tolerance toward pollution. Then, tolerance value of all taxa in the sample was totally up altogether to produce tolerance score and then water quality was classified according to BMWP water quality classification. BMWP-Thailand was a modified version of BMWP with some addition, elimination, and regroup of macroinvertebrate group, according to data of macroinvertebrate found in Thailand. SingScore were developed according to procedure based on [2] which involved two-step process; 1) multivariate ordination techniques to determine the environment variable that best explained in macroinvertebrate community composition, 2) weighted averaging (WA) techniques to calculate the tolerance score of macroinvertebrate family. Last but not least, BMWP-My also were modified from the original BMWP which based on data of macroinvertebrate in Malaysia region.

## 2.4. Cluster analysis

The scores of biotic indices were classified into four scoring patterns which excellent, good, moderately-good and poor and biotic indices were compared by using UPGMA cluster analyses by Morisita similarity index by using Paleontological Statistics Software Package (PAST) software.

## 3. Result

There are 2692 individuals of aquatic insect comprising of 45 families from nine orders. From the result, family with the highest number of individuals was Hydropsychidae from order Trichoptera, with 666 individuals followed by Perlidae from order Plecoptera with 556 individuals and Baetidae from order Ephemeroptera with 386 individuals (Figure 5, 6 and 7). There are nine singleton family were found during sampling work which is Caenidae, Leptoceridae, Hydrobiosidae, Lepidostomatidae, Glossomatidae, Hydroptilidae, Chlorocyphidae, Aphelocheiridae and Hydrochidae.



**Figure 5.** Family Hydropsychidae



**Figure 6.** Family Perlidae



**Figure 7.** Family Baetidae

A separate paper is being prepared to report on the diversity of aquatic insects obtained from Sg Batang. Diversity of aquatic insects from here was then compared to other river systems in Johor. It is possible

to make comparison with other river systems in Johor since extensive collection had been done in seven sites from date to date.

In this study, there are four biotic indices were used which Biological Monitor Working Party (BMWP), BMWP-Thailand, SingScore and BMWP-Malaysia. Table 2 shows the score pattern for BMWP and SingScore which 0 refer to excellent water quality and 3 refer to poor water quality. Based on scores and value shows in Table 3 below, BMWP were ranging from 'Moderately-good to Good', BMWP-Thai were indicate 'Good' in water quality, SingScore were indicate 'Excellent' in water quality and BMWP-My score ranging from 'Good to Excellent' in water quality. Table 2 shows the score pattern for BMWP and SingScore index

**Table 2.** Score pattern of biotic indices

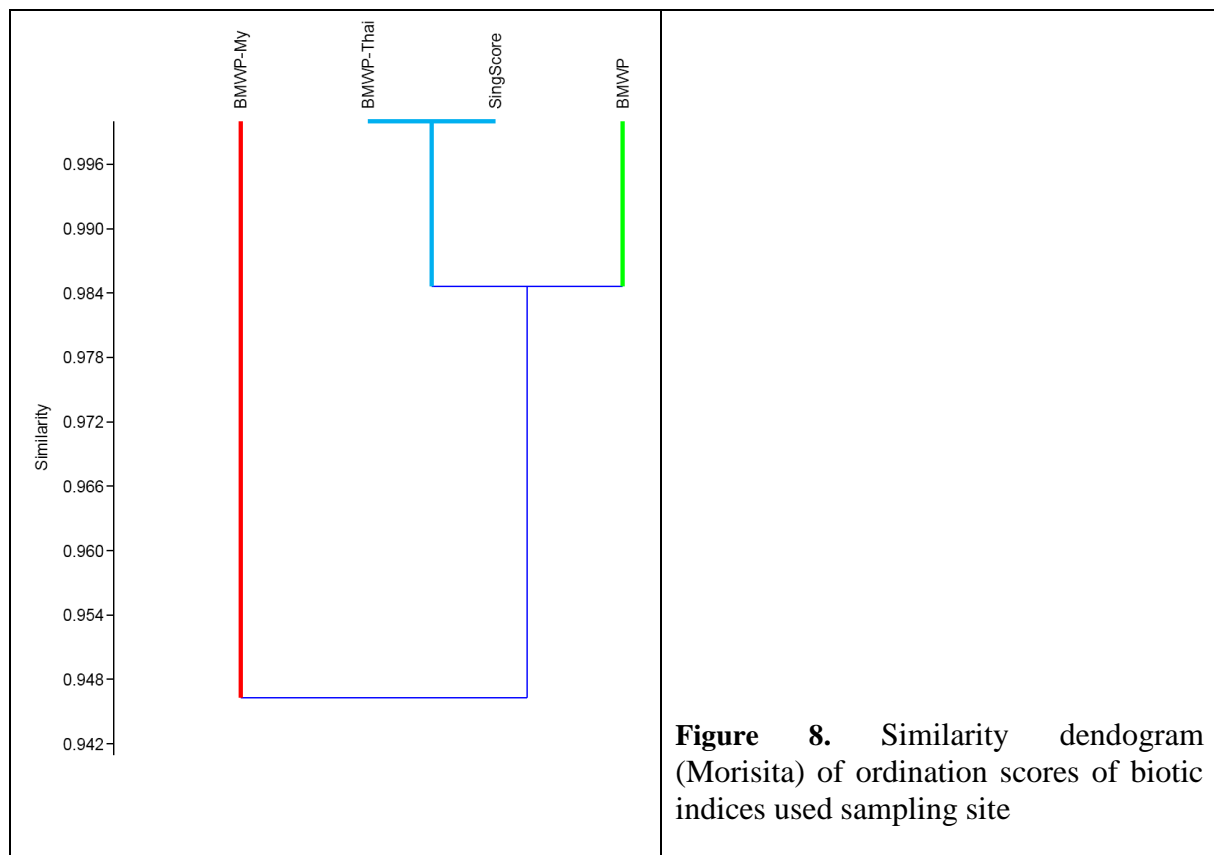
	BMWP	SingScore
0	Excellent	Excellent
1	Good	Good
2	Moderately-good	Fair
3	Fair	Poor
	Poor	

**Table 3.** Score and values of biotic indices used in sampling site

Biotic indices	BMWP	BMWP-Thai	SingScore	BMWP-My
R1	111 (G)	124 (G)	156 (EX)	178 (EX)
R2	100 (MG)	115 (G)	149 (EX)	175 (EX)
R3	94 (MG)	103 (G)	120 (EX)	136 (G)
Total	100 (MG)	105 (G)	176 (EX)	224 (EX)

\* EX = Excellent, G = Good, MG = Moderately-good

Based on the analysis of the similarity (Figure 8), red line which represents BMWP-My shows very least similarity to the others with 0.946 similarity value and the two most similar biotic indices were BMWP-Thai and SingScore with 1.0 similarity value.



## 4. Discussion

### 4.1. Species composition dan diversity

Based on community composition, shows that Hydropsychidae, Perlidae and Baetidae were dominating the sampling sites and as we know based on many literatures all of them were classified as clean water species. Most of this group such as baetids and philopotamids they favored sites with full of pebbles and gravels since they are live and feed on the sides and bottom of rocks and make rocks as their homes by forming a protected shelter that made of silk and debris [9]. From an observation, Hydropsychidae were found numerous attached to the surface of rocks with full of forest cover and Heptageniidae also favor a fast-flowing stream with stable substrates [16] and if any, physical changes happened to the stream could influence the composition and diversity of aquatic insects [6].

### 4.2. Biotic indices

Every recent year, development rate in Malaysia was drastically increased due to the increases of human population. Undoubtedly, the development is very crucial as to fulfill the human needs, but development, supposedly without ignoring the environmental aspects seems its providing us a natural resources such as clean water, timber product and food. Water resources are a one of important resources that need more attention because it became a major need for human or wildlife as for life sustaining. Therefore, monitoring water quality became a necessary in Malaysia. In monitoring water quality, physical and chemical techniques were very popular across the world, but as Malaysia is a developing country those techniques quite expensive and time consuming because a lot of procedure are involved especially if numerous parameter were measured [17].

Alternatively, there are proven technique in monitoring water quality which is by using macroinvertebrates as a tool for monitoring. Compared to the other two methods, this method is more user friendly as they are not too expensive and fast since no complicated procedure involved. Moreover,



they are very sensitive to environmental changes, able to detecting several types of pollution, ubiquitous and diverse which make them a good bioindicator to both good and poor water quality [12;18]. They are also capable to investigate the pollution which occur over period of time due to the long life cycle of certain species [13]. All these reasons should be taken into account in making critical decisions in determining the best biodiversity management to avoid losses in the review caused by errors in decision making. Thus, a lot of biotic indices were developed especially in Europe region. In developing countries, biological monitoring are still restricted because of lacking in information regarding the effectiveness of techniques since most of biotic indices were developed according to Europe nor North American region data [15].

Based on the result, BMWP shows with the least reflect on health of stream because many aquatic insects are not listed in BMWP tolerance value and some of them could become an important group in biological monitoring in the river system in Malaysia region. Since BMWP was originally developed in U.K and as we know due to the difference of geographic range the composition of aquatic insect communities are different. Some of aquatic insects were found in tropical region but absent in the other regions [17]. According to [15], during the development of BMWP-Thai there are thirty three families present in Thailand, but absent in the UK and some of them might be useful in the water quality indicator. There are also several families in BMWP score did not find in Thailand.

According to comparative analysis results, BMWP-My was found as very least similarity to other indices and the factor that might influence the result was most of the aquatic insects found in sampling site were included in BMWP-My tolerance score since the purpose of the development of this index was to evaluate the water quality in Malaysia water bodies. BMWP-Thai and SingScore was much closed to each other. As expected since they came from the same region, so the differences in term of the composition of aquatic insects was not significant.

Since our data are within the river system in Malaysia, we believed that BMWP-My was the best biotic index in reflecting the health of the river system because most of the aquatic insects found in sampling site were present and calculated in BMWP-My and because of that the score should be more accurate compared to the others.

**Table 4.** Physio-chemical score according to WQI value

<b>Water parameters</b>	<b>Batu Pahat WMS (Sg. Bantang)</b>	<b>Water Quality Index</b>
DO	<b>I</b>	99.89
BOD	<b>II – IV</b>	79.25
COD	<b>I – III</b>	81.01
TSS	<b>I</b>	96.30
pH	<b>II</b>	112.94
NH <sub>3</sub> .NL	<b>I</b>	97.60
WQI		<b>94.16</b>

## 5. Conclusion

Hutan Lipur Sungai Bantang (HLSB) ecosystem were provided a good physical and chemical variable which their water quality is ranging from moderately- good to excellent based on the composition of aquatic insects and water quality index (WQI). Despite of rapid development happened in Johor, we managed to collect 45 families of aquatic insects and half of them are clean water species which there are still worth it to be conserve and very useful in biological monitoring. From the result, BMWP-My was the most suitable biotic index to use in Malaysia water body since its give better reflect on the health of the river system. Finally, the uses of aquatic as biological monitoring tools were recommended

because aquatic insects found almost in every freshwater habitat, their diversity and their sensitivity to environmental changes which make them a good biological indicator.

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### Appendices

**Table A1** Tolerance value for biotic indices [14, 15,17,20]

Order	Family	MTV	BMWP	BMWP-Thai	SingScore
Ephemeroptera	Baetidae	6	4	4	7
	Caenidae	4	7	7	7
	Ephemerellidae	5	10	10	
	Ephemeridae	6	10	10	
	Heptageniidae	6	10	10	9
	Isonychidae	7			
	Leptophlebiidae	6	10	10	10
	Neophemeridae	7			
	Potamanthidae	6	10	10	
	Prosopistomatidae	8			
	Siphonuridae			4	
	Tricorythidae	5			
Odonata	Aeshnidae	8	8	6	9
	Agriidae		8	6	
	Amphipterygidae	5			10
	Calopterygidae	7		6	8
	Chlorocyphidae	5		6	
	Chlorogomphidae	9			
	Coenagrionidae	5	6	6	3
	Cordulegastridae		8	6	
	Cordullidae	6	8	6	5
	Euphaeidae	6			9
	Gomphidae	5	8	6	8
	Lestidae		8	6	
	Libellulidae	5	8	6	4
	Platycnemididae	5	6	6	5
	Platystictidae	5			8
	Protneuridae	7		3	
Plecoptera	Nemouridae	9	6	6	
	Peltoperlidae	6			
	Perlidae	6	10	10	9
Hemiptera	Aphelocheiridae	8	10	10	
	Belastomatidae				
	Corixidae	6	5	5	10
	Gerridae	5	5	5	5

	Helotrephidae	6			4
	Leptopodidae	6			
	Naucoridae	6	5	5	7
	Notonectidae	5	5	5	8
	Pleidae	5	5	5	
	Veliidae	6	5	5	7
Megaloptera	Corydalidae	7		4	
	Sialidae	5	4	4	8
Trichoptera	Apataniidae	7			
	Arctopsychidae			5	
	Brachycentridae			10	
	Calamoceratidae	5			
	Dipseudopsidae			7	
	Ecnomidae	7			6
	Glossosomatidae	5			
	Helicopsychidae	7			
	Hydropsychidae	5	5	5	7
	Lepidostomatidae	9	10	10	
	Leptoceridae	6	10	10	7
	Odontoceridae	8	10	10	10
	Philopotamidae	6	8	8	8
	Polycentropodidae	5	7	7	9
	Sericostomatidae	5	10		
	Stenopsychidae	6		7	
	Xiphocentronidae	5			
Lepidoptera	Crambidae				5
	Pyralidae	5			
	Chrysomalidae	5	5	5	
	Dryopidae	6	5	5	
	Dystictidae	6	5	5	5
Coleoptera	Elmidae	5			
	Eulicadidae	7			
	Gyrinidae	5	5	5	
	Haliplidae	5	5	5	
	Hydraenidae	5			8
	Hydrochidae	7			
	Hydrophilidae	6	5	5	6
	Hydroscapidae	5			
	Lampyridae	6			
	Noteridae	4			
	Psephenidae	5		5	
	Ptilodactylidae	7			
	Scirtidae	6			8
Diptera	Athericidae	5			10
	Ceratopogonidae	6			3
	Chironomidae	1	2	2	2
	Dolichopodidae	7			1
	Empididae	7			4
	Sciomyzidae	5			
	Simuliidae	5	5	5	7
	Stratiomyidae	5			

Syrphidae	1			4
Tabanidae	5			
Tanyderidae	5			
Tipulidae	6	5	5	3

**Table A2.** Scores of Biological Monitoring Work Party (BMWP) [19]

Biotic index criteria (BMWP)	Water quality rating
> 150	I Excellent
101 – 150	II Good
51 – 100	III Moderately- good
17 – 50	IV Fair
0 – 16	V Poor

**Table A3.** SingScore water quality categories [10]

SingScore	Water Quality
079	Poor
8099	Fair
100119	Good
>120	Excellent

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