BENTHIC MACROINVERTEBRATES DIVERSITY AND COMPOSITION AT LATA JANGGUT RECREATIONAL AREA, KELANTAN, MALAYSIA

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ABSTRACT

Lata Janggut is a public-focused recreational area with a high possibility of changes in biodiversity involving benthic macroinvertebrates, reflecting the water quality and health of Lata Janggut itself. Therefore, this study was carried out to determine the river health and water quality of Lata Janggut using benthic macroinvertebrates through common biotic indices. Benthic macroinvertebrates were collected monthly at nine points from three stations, i.e. three points at down-stream (ST1), middle-stream (ST2) and up-stream (ST3), respectively. The sampling protocols have followed Karr's Aquatic Insect Stream Sampling Protocol. The benthic macroinvertebrates were identified based on key identification published by Thorp and Covich, Gooderham and Tsyrlin Mekong River Commission (MRC). Biological Monitoring Working Party (BMWP) index, Family Biotic Index (FBI), and Ephemeroptera, Plecoptera and Trichoptera (EPT Index) were used as biotic indices, and Mann-Whitney U was also used as a comparison test of macroinvertebrates compositions. A total of 4037 macroinvertebrates, comprising eight orders, thirty-two families, and thirty-one genus, were recorded. These include the order of Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Diptera, Hemiptera and Odonata. It shows that ST2 ($U=73$, $P=0.05$) and ST 3($U=88.5$, $P=0.02$) were significantly higher in compositions than ST1. Apart from that, the benthic macroinvertebrate composition during March was significantly higher than compositions during April to July ($U\leq10$, $P<0.05$). Biotic indices indicate that ST1 has recorded Moderate BMWP (21.0-58.0), Excellent FBI (1.43-3.61) and Fair EPT Index (4-12), while ST2 has recorded Clean BMWP (31-67), Excellent FBI (1.69-3.69) and Fair EPT Index (5-13). Thus, ST2 has recorded a better biotic index value as compared to ST1. Nonetheless, ST3 has recorded Moderate BMWP (31-56), Excellent FBI (1.79-3.53) and Fair EPT Index (5-8). Overall, the biotic indices measured in Lata Janggut have indicated moderate disturbance, river health, and water quality, specifically downstream with high recreational activities.

Keywords: Biotic Index, benthic macroinvertebrate, BMWP, FBI, EPT, river quality

ABSTRAK

Lata Janggut adalah kawasan rekreasi berfokus kepada orang awam dengan kemungkinan besar perubahan kepelbagaian biologi yang melibatkan makroinvertebrata bentik, yang mencerminkan kualiti air dan kesihatan Lata Janggut. Oleh itu, kajian ini dilakukan untuk mengetahui kesihatan sungai dan kualiti air Lata Janggut menggunakan makroinvertebrata bentik melalui indeks biotik biasa. Makroinvertebrata bentik dikumpulkan setiap bulan pada sembilan kawasan dari tiga stesen, iaitu tiga titik pada aliran bawah (ST1), aliran tengah (ST2) dan aliran atas (ST3), masing-masing. Protokol pensampelan telah mengikuti Protokol Persampelan Aliran Serangga Akuatik Karr. Makroinvertebrata bentik dikenalpasti berdasarkan pengenalan utama yang diterbitkan oleh Thorp dan Covich, Gooderham dan Tsyrlin Mekong River Commission (MRC). Indeks Parti Kerja Pemantauan Biologi (BMWP), Indeks Biotik Keluarga (FBI), dan Ephemeroptera, Plecoptera dan Trichoptera (Indeks EPT) digunakan sebagai indeks biotik, dan Mann-Whitney U juga digunakan sebagai ujian perbandingan komposisi makroinvertebrata. Sebanyak 4037 makroinvertebrata, yang terdiri daripada lapan order, tiga puluh dua famili, dan tiga puluh satu genus, direkodkan. Ini termasuk susunan Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Diptera, Hemiptera dan Odonata. Ini menunjukkan bahawa ST2 (U=73, $P=0.05$) dan ST3 (U=88.5, P=0.02) secara signifikan lebih tinggi dalam komposisi daripada ST1. Selain itu, komposisi makroinvertebrata bentik pada bulan Mac jauh lebih tinggi daripada komposisi pada bulan April hingga Julai ($U \leq 10$, $P<0,05$). Indeks biotik menunjukkan bahawa ST1 telah mencatatkan BMWP Sederhana (21.0-58.0), FBI Cemerlang (1.43-3.61) dan Indeks EPT Cukup (4-12), sementara ST2 mencatatkan BMWP Bersih (31-67), FBI Cemerlang (1.69- 3.69) dan Indeks EPT Sederhana (5-13). Oleh itu, ST2 telah mencatatkan nilai indeks biotik yang lebih baik berbanding dengan ST1. Meskipun demikian, ST3 telah mencatatkan Moderate BMWP (31-56), FBI Cemerlang (1.79-3.53) dan Indeks EPT Sederhana (5-8). Secara keseluruhan, indeks biotik yang diukur di Lata Janggut menunjukkan gangguan, kesihatan sungai, dan kualiti air sederhana, khususnya di hilir dengan kegiatan rekreasi yang tinggi.

Keywords: Indeks Biotik, makroinvertebrata bentik, BMWP, FBI, EPT, kualiti sungai

INTRODUCTION

Lata Janggut is one of the recreational rivers located in Jeli, Kelantan (Mat Nazari et al. 2020). For recreational activities, this river has been visited by local communities. Uncontrolled recreational activities may lead to changes in river ecosystems, thus impacting the quality of the river itself. Still, there is not much assessment have been done to determine the river's health due to a lack of awareness on river sustainability. In addition, the physicochemical water quality assessment (Appalasamy et al. 2018; Azrina et al. 2006; Salam et al. 2019) required a high cost as well as time-consuming. Furthermore, it can only show the water quality at the time the measurement is taken not the current situation of the river water quality. Lata Janggut is a flowing river with dynamic changes over time, based on its surrounding activities. Therefore, benthic macroinvertebrates can be a good bioindicator in assessing the river's health (Parmar et al. 2016).

Macroinvertebrates do not have a backbone and are sufficiently huge to be seen with the naked eye. Benthic macroinvertebrates are exothermic and may be aquatic or terrestrial, while aquatic macroinvertebrates are tiny animals like water bugs that spend almost all or a part

of their lives underwater (Ligeiro et al. 2013; Mabidi et al. 2017). Microinvertebrates' instances include flatworms, crawfish, snails, molluscs, and insects such as dragonflies (Ganguly et al. 2018). Insects start their life cycle as an egg and experience physical changes within each phase in their life cycle (transformation). For instance, caddisflies have four phases of life, while mayflies and stoneflies have just three organises with complete and fragmented transformation (Patang et al. 2018). Insects look and exist in an unexpected way at each stage. A portion of these is sensitive to contamination, while others can live in exceptionally dirty waters. In light of this fluctuation in affectability to contamination, macroinvertebrates make great biological indicators.

Examining the types and composition of macroinvertebrates present in a river can indicate how healthy the river is (Patrick 2015). Various kinds of macroinvertebrates can endure diverse stream state and amount of contamination. Hence, their essence or nonattendance are utilised to show different levels of water cleanliness (Patrick 2015). For instance, most larvae of caddisflies, mayflies, and stoneflies cannot survive in the contaminated water. Therefore, streams with these bugs are expected to have excellent water condition. Dirty water is normally due to the pollution which enters the water body either through the discharge of oily wastewater (Bujang et al. 2012) from the automotive workshop, wastewater from domestic, shop lot or soil erosion, sediments carrying organic matters (Azlan et al. 2011) into the river. However, the absence of these living beings in a water body does not determine that the water quality is poor. This is because their presence also relates to other common variables include habitat characteristics, river morphology, river riparian, canopy cover, and substrate compositions (Rak et al. 2010).

Other than the presence and absence of individuals benthic macroinvertebrates, Biotic Indices likewise can be used as an indicator to assess river water quality and river health. BMWP, FBI and EPT Index is common biotic index used in assessing water quality and river health. The Biological Monitoring Working Party (BMWP) Index was built utilising various chose benthic taxa characterised by their resistance to natural contamination. Contamination intolerant families have high score esteems, while contamination tolerant families have low score esteems.The score of esteems is from 1 to 10. In order to determine the BMWP, all the individual scores of all the families present in a sample are summed. High BMWP values are criteria of clean sites, while low BMWP values are representative of contaminated sites. However, BMWP index also has been modified to suit the regional compositions especially for asean regional such as Thailand, Vietnam and Malaysia (Hui & Fikri 2021). Hui and Fikri (2021) also studied the sensitivity all biotic index in selected river in Sabah, Malaysia and found three indices that shows high sensitivity toward human distribution such as EPT, BMWP-Viet, and BMWP-My.Meanwhile, the Family Biotic Index (FBI) is the adjusted form of the Biotic index initially structured by Hilsenhoff (1988). The FBI was created to identify organic contamination: it incorporates macroinvertebrates other than arthropods and uses family-level tolerance esteems (Hilsenhoff 1988). Tolerance esteems assigned from 0 for creatures that are very intolerant to organic contamination to 10 for extremely tolerant organic contamination creatures. In determining the FBI, living beings can be recognised at a family level, and negligible taxonomic expertise is essential. In addition, the measurement considers macroinvertebrates other than arthropods and contain abundance and rich parts for its computation.

On the other hand, the EPT Index is the total number of particular taxa inside the gatherings, Trichoptera, Ephemeroptera, and Plecoptera. For instance, if five types of Ephemeroptera (mayflies), five Plecoptera (stoneflies), and two Trichoptera (caddisflies) are

found at a site, the all-out number of EPT taxa and index would be approaching 12. For this situation, the EPT Index would rise to 12. The EPT Index is then contrasted with qualities on an EPT rating diagram. Many state water quality divisions are a decent wellspring of data on the most proficient method to build up a rating graph for a specific ecoregion. The EPT Index increments with better water quality like there ought to be a more noteworthy number of EPT taxa in cleaner water. Evaluations are customised to represent contrasts in species contamination resistance in the middle areas. Lata Janggut is one of the recreational river in Jeli and expose to the human disturbance via recreational activities and human settlements. Therefore it is important to identify the status of the river to promote the sustainable river activities via organisms that exposed to the any changes such as benthic macroinvertebrates. Thus. this study aims to determine river water quality as well as river health by using the common biotic indices for benthic macroinvertebrates of Lata Janggut. This study also discusses the monthly biotic indices and benthic macroinvertebrates compositions for six months.

MATERIALS AND METHODS

Study Area

This study was carried out at Lata Janggut, located in the Jeli district, Kelantan, Malaysia. In particular, Jeli, a region in Kelantan, is a remote zone that is still preserved and green. In the Jeli district, visitors can visit many nature recreational places, such as Gunung Reng, Pergau River, Lata Chenai, Lata Janggut, and Lata Renyok and Jeli hot spring. Lata Janggut, which is an extension of Sungai Long, is one of the captivating falls in the Jeli region, Kelantan. The samples were collected at three pre-determined stations located at the river's lower, middle and upper reaches (Figure 1). There were three replicas of samples per stations. In total, nine samples were collected monthly from March 2019 till August 2019.

Figure 1. Three selected study sites in Lata Janggut comprising ST1 (downstream), ST2 (middle) and ST3 (upstreams)

(Source: Google map)

Insect Sampling

The sampling protocols followed in this study were adapted from Karr's Aquatic Insect Stream Sampling Protocol (Karr 1998). Each station comprises three sampling points; the right bank,

at the middle, and at the left bank. All three samples in each sampling station were compounded as one sample. The insect collection using a Surber Net with 500 microns mesh size combined with a rectangular quadrate of 30 cm x 30 cm (0.09 m^2) in size. The surber net into which the disturbing benthic invertebrates were swept in by the current (Duran 2006). The use of the Surber Net for benthic macroinvertebrate sampling was considered quantitative sampling. The purpose of the two triangular wings of the net, linking the two frames' lateral margins, was to reduce the loss of sample around the sides of the net. Benthic macroinvertebrate sample was preserved in 80% of ethanol before being sent to the laboratory for species identification.

Species Identification

Samples were identified up to the genus level (Gooderham & Tsyrlin 2002; Thorp & Covich 1991) by using biological binocular microscope model Y-100 Rax Vision.

Data Analysis

Mann-Whitney U test was used to compare different stations compositions of benthic macroinvertebrates monthly. Next, Biological Monitoring Working Party (BMWP), Family Biotic Index (FBI) and Ephemeroptera, Plecoptera and Trichoptera (EPT) Index were used to determine the monthly river health and water quality in Lata Janggut from March 2019 till August 2019 (Mandaville 2002; Omar et al. 2014).

RESULTS AND DISCUSSION

A total of 4037 individuals macrobenthic invertebrates comprising of eight orders, 32 families, and 32 genera were recorded. However, those macrobenthic invertebrates collected was mainly aquatic insects such as Ephemeroptera, Trichoptera, Coleptera, Diptera, Odonata, Hemiptera and Plecoptera. The individual recorded was more than five times higher than what was recorded in Pergau Lake, Jeli, Kelantan (733 individual) (Syed Omar et al. 2020) and more than three times than what was recorded in Lata Meraung, Pahang, Malaysia (1287 individuals) (Sharifah Aisyah et al. 2015). It was also 22 times higher as compared to the number of macroinvertebrates recorded in Sungai Dawai and Sungai Dekong (182 individuals) in Lojing Highland, Gua Musang, Kelantan (Omar et al. 2014). These include the order of Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Diptera, Hemiptera and Odonata. The relative composition of the major taxonomic groups to the overall benthic macroinvertebrates population at the different sampling stations have revealed that the study area is dominated by Ephemeroptera (34%), Trichoptera (32%), Coleoptera (2%), Diptera (24%), Odonata (2%), Plecoptera (5%) and Hemiptera (1%). These groups were well represented in the three sampling sites: Upper, middle and lower reaches, as these areas are located upstream of Sungai Long. The results are in line with the findings from Yule and Yong (2004) and Etemi et al. (2020). However, the result of macrobenthic from Lata Janggut has indicated that it is much better in terms of water quality and river health than other places in the same river usage (recreational). This can be supported by finding from Hui and Fikri (2021) in Sabah which sampling location is at disturb area composed less Plecoptera and Trichoptera compositions compared to Diptera compositions.

The trend shows that higher number of macroinvertebrates benthic were collected in March ($U \leq 10.0$, $P<0.05$) and August ($U \leq 38.0$, $P>0.05$) at all stations. The highest number was collected in March at ST 3 (657 individuals), followed by August ST2 (464 individuals) and ST3 (420 individuals), and the lowest was recorded in July, ST1 (54 individuals). The number of macroinvertebrates was lesser in the month of April until July at all stations with no

significant difference in compositions (*P>0.05*), as it has shown a fluctuating pattern in Figure 2.

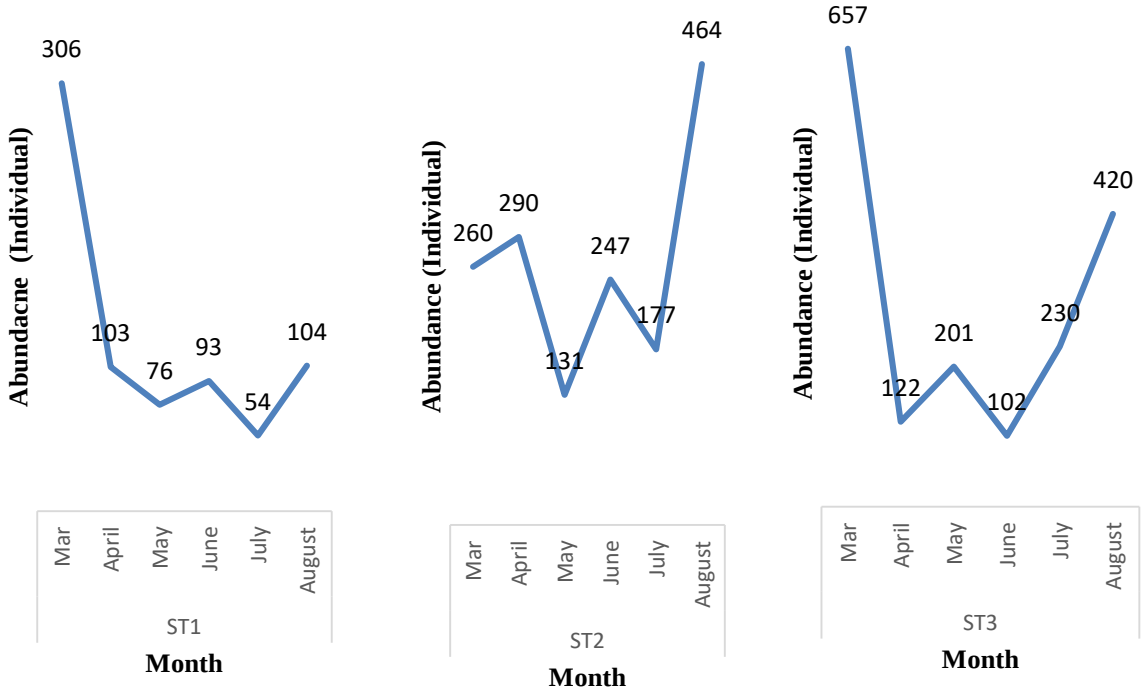

Figure 2. Trend of monthly individual macroinvertebrate benthic collected

Biotic index values measured for the BMWP index for ST 1 located downstream were between 21.0 to 58.0 and categorised as moderately impact river. Meanwhile, the BMWP value for ST2, which is located at the middle stream, was between 31.0 and 67.0 and can be categorised as clean but slightly impacted and ST3 at the upstream, which was under moderately impact with BMWP values between 31.0 and 56.0. The results obtained was much higher as compared to the value recorded at Sungai Dekong (2.0-12.0), and it was lower as compared to the value recorded in Sungai Dawai (26.0-84.0) at Lojing, Gua Musang, Malaysia (Aweng et al. 2015). However, it was lower as compared to the value recorded at Kargı Stream (41-132) in Turkey (Zeybek 2017) and at the coastal river of Paraná state (82-174), Southern Brazil (Gonçalves & de Menezes 2011). BMWP has decreased from March till July at ST1 and March till May at ST2. However, the highest reading (67.0) was recorded in March at ST2, and the lowest (21.0) was recorded in July at ST1. Apart from that, BMWP values for ST3 have indicated a slight change in BMWP value, although the BMWP values have fluctuated from May till August as the values have dropped to 31.0 from 51.0 and increased back during July to 56.0 before August drop to 46 in August (Figure 3).

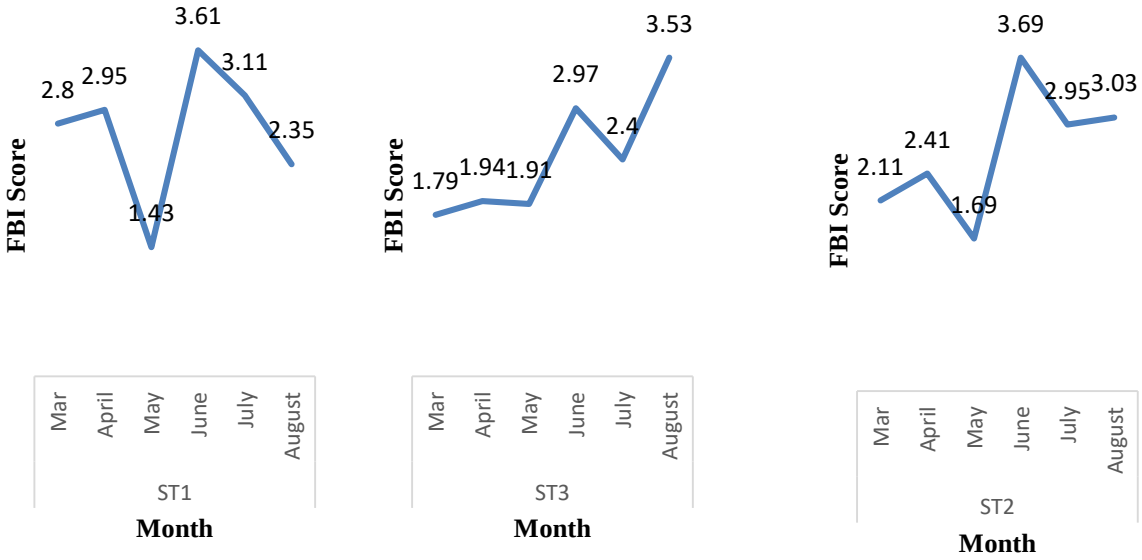

Figure 3. Trend of monthly BMWP for three station

Conversely, the results of FBI at all sampling stations fall within the Excellent Water Quality category whereby ST1, which is located downstream, has recorded between 1.43 to 3.61, ST2 located at the middle stream has recorded between 1.69 to 3.69 and for ST3 located at the upstream, has recorded between 1.79 and 3.53. Overall, FBI values were high in June and low in March, April, May, July and August for all the stations. The results obtained are lower as compared to the value recorded at Sungai Dekong (5.3-6.0) and Sungai Dawai (3.1-4.3) at Lojing, Gua Musang, Malaysia (Aweng et al. 2015). However, the highest (3.69) was recorded in June at ST2, and the lowest (1.69) was recorded in May at ST 2 (Figure 4).

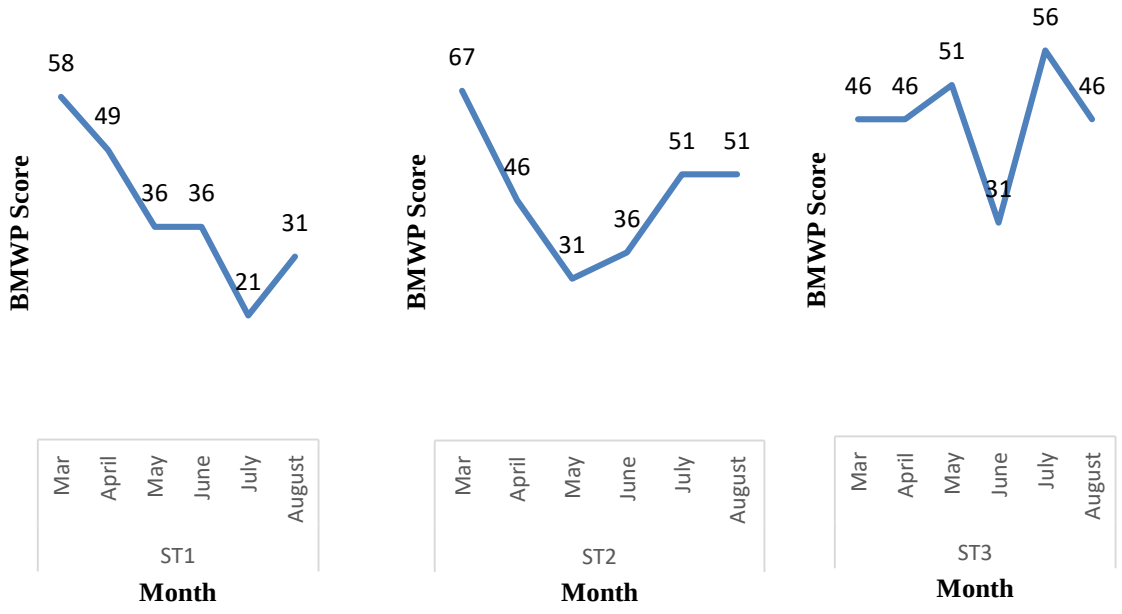

Figure 4. Trend of monthly FBI for three station

Altogether, 1094 individuals Ephemeroptera, 171 individuals Plecoptera and 1235 individuals Trichoptera in Lata Janggut with five (5) families of Ephemeroptera, two (2) families of Plecoptera and ten (10) families of Trichoptera were found. The Ephemeroptera was the most abundant EPT compared to Trichoptera and Plecoptera at the stream. ST2 has recorded the highest EPT taxa richness index with 65 taxa, followed by ST3 (59 taxa) and station 1 with 49 taxa. The 173 genera found in all station are represented by varied composition pattern. Among nine Ephemeropterans genera encountered, *Nigrobaetis* sp. was the most common genus, with its greatest abundance occurred in all station from March until August. It was followed by *Platybaetis* sp. while *Crinitella* sp. was the third most common genus of Ephemeroptera. Besides, Ephemeroptera genera which is *Cinygmina* sp. were absent in ST1 and ST3 in all months, but only few of them were found in ST2 in March. The recorded family of Plecoptera at Lata Janggut are Perlidae and Peltoperlidae. *Neoperla* sp. (Perlidae) was the most abundant genus in the three stations. The highest abundance of *Neoperla* sp. was found in ST2 and the least in ST3. It was followed by *Phanoperla* sp. which was also abundant in ST2 and ST3 and fewer in ST1. Among the Trichopterans, *Stenopsyche* sp. was the most common genus found. Its abundance was the highest in ST1, followed by *Hydromanicus* sp. In terms of EPT index, ST1, which is located downstream, recorded between 4.0 to 12.0, ST2 recorded between 5.0 to 13.0 and ST3 recorded between 5.0 to 8.0. All stations can be categorised as having a fair water quality. The results obtained are much higher as compared to the value recorded at Sungai Dekong (0.0) and Sungai Dawai (2.0-5.0) at Lojing, Gua Musang, Malaysia (Aweng et al. 2015). On the other hand, it is lower than the value recorded at the coastal river of Paraná state, southern Brazil (Gonçalves & de Menezes 2011). EPT index was high in March and August and low in April, May, June and July at all stations except ST3. The results are also in line with the findings published by Suhaila and Che Salmah (2017a,b), where they stated that in the early wet season (August), the distribution of Ephemeroptera would rise a little bit. Dhiya Shafiqah et al. (2020) also found the highest EPT during dry season compared to wet season. It is also in line with Gonçalves and de Menezes (2011) findings, where they recorded a low EPT index indicating bad water quality in April. However, the highest (13.0) was recorded in March at ST2, and the lowest (4.0) was recorded in May and July at ST1 (Figure 5). In contrast, ST3 EPT index indicates only small changes from March till August.

Figure 5. Trend of monthly EPT Index for three stations

CONCLUSIONS

Lata Janggut records a very high number of individuals but less in terms of benthic macroinvertebrates diversity. In addition, the biotic indices recordde has shown only one index that indicates the river is in the "excellent" category, namely the FBI. In contrast, other indices portrayed the river has been disturbed. Thus, it can be concluded that Lata Janggut has been affected, and the authorities need to take action in order to restore and sustain the river quality of Lata Janggut by limiting the number of visitors, running a campaign to create awareness on hygienic practices among visitors or even by tightening the law enforcement.

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