Zooplankton study in Bukit Merah Reservoir, Malaysia: a preliminary biodiversity assessment

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Abstract. Anthropogenic activities including uncontrolled development and agricultural intensification in the catchments area accelerate the sedimentation rate in lake and reservoir. Bukit Merah Reservoir is one of the freshwater ecosystems facing sedimentation issue and a major threat to its water quality from anthropogenic activities. These activities lead to invariably changing in water quality parameters and become the primary cause of variations to aquatic biodiversity such as zooplankton. This study investigated the biodiversity of zooplankton as a preliminary assessment in Bukit Merah Reservoir, the oldest artificial reservoir in Malaysia. Water and zooplankton samples were collected from six sampling stations which cover the littoral, limnetic and pelagic zones of the reservoir. Zooplankton analysis showed the presence of 49 taxa belonging to the three main groups of freshwater zooplankton dominated by Keratella cochlearis, Trichocerca sp., Polyarthra sp., Bosminopsis deitersi and Diaphanosoma sp. Analysis of variance revealed a significant difference was found (P<0.05) between the sampling stations during the study period. Zooplankton biodiversity reflects the water quality condition at the time of sampling that indicates the health of aquatic water body in the study site.

1. Introduction
Bukit Merah Reservoir is the oldest artificial reservoir in Malaysia that was built in 1906. The main reason for the building of the reservoir is to supply irrigation water for double cropping to about 24 000 ha of paddy land. Additionally, approximately 5.6 cusecs of water are being supplied to fulfil the domestic and industrial demands of the Kerian District. Other than that, it is the source of income for the local fisherman [1].

Currently, there are several problems encountered by Bukit Merah Reservoir including storage depletion and floating vegetation due to sedimentation caused by land-use activities such as land clearing, the building of train tracks and sand mining operations. These activities have affected water quality and many aquatic organisms in the reservoir. Floating vegetation growth of common Susum (Hanguana malayana) and water hyacinth (Eichhornia crassipes) become the major threat for the lake structure’s stability as it will consume the water and causes the lake to become smaller in size. It has been estimated that 40% of the watershed area (the northern/eastern portion) is covered by floating and aquatic vegetation [2]. Fertilizers and nutrient runoff from plantations are also flowing into the upper
catchment area, promoting the growth of these weeds. The train tracks construction, together with 7 sand mining operations along the Kurau River leads to the increase of water turbidity

Numerous studies documented on the consequences of biodiversity change in parallel with anthropogenic impact. Increasing human population and destructive activities on Bukit Merah Reservoir demand huge load on aquatic life, suggesting that anthropogenic impact significantly affect organisms such as fish, zooplankton, phytoplankton, microorganisms and macroscopic plants. For example, plankton provide the base for the entire aquatic food web. Zooplankton eat phytoplankton and then become food for fish, and other larger species. The existence and sustainability of zooplankton are very important for healthy aquatic ecosystems. In light of today’s knowledge, due to their fundamental position in pelagic food webs [3], zooplankton play a vital role as intermediate trophic level organisms in lakes and reservoirs.

The deterioration in water quality from natural and anthropogenic activities on Bukit Merah Reservoir has become a central concern. Thus, it is very crucial to evaluate the biodiversity of zooplankton in Bukit Merah Reservoir which will, in turn, indicate the health of its water quality. This study aimed to determine the distribution of zooplankton community in the reservoir that might have potential to be used as biological indicator of water quality condition in the study site.

2. Materials and Methods

2.1. Study Site

The study was conducted in Bukit Merah Reservoir (5° 00' 53.17'' N, 100° 40' 06.08'' E) in Perak state of Peninsular Malaysia (Figure 1). Bukit Merah Reservoir is situated in Kerian District, a northern part of Perak State. The source of water for the reservoir came from four (4) rivers which flow through Pondok Tanjung Forest Reserve (6718 ha): the rivers of Kurau (83.31 km); Merah (4.25 km), Jelutong (7.1 km) and Selarong (3.1 km) [4]. The average water depth of the reservoir is 2.5 m while the maximum depth is 5.3 m [5].

Figure 1. Location of Bukit Merah Reservoir and the 6 sampling stations during the study period.
The main purpose of the built is to provide irrigation water to Kerian Irrigation Scheme and also to provide domestic water supply for Kerian and Larut Matang District. The reservoir is also known for their original sanctuary of Arowana Malayan Gold, the high quality of freshwater fish in the world [6]. It is covered by two districts, Kerian District and Larut Matang, with 92.8 million cubic meters volume of water.

The range of surface water temperature is between 27.48 ºC – 29.9 ºC. The rainfall level is the highest during the months of March to May and October to November correlates with higher precipitation in these periods. According to [6], the reservoir is deeper on the west part and shallower on the east part. The released of water from Bukit Merah dam for agricultural activities has also been stopped to focus on domestic use.

2.2. Sampling Method
Six sampling stations were established in this study which covers the littoral (near shore area) and limnetic (open water area) zones of the reservoir (Figure 1). At each station, three sample replicates were collected. Stations 2, 3 and 4 are situated at the northern reservoir while Stations 1, 5 and 6 are located at the southern reservoir.

Field sampling was carried out monthly from October until December 2015. Regarding the water sampling, there are several types of water sampler, such as Niskin, Van Dorn and Nansen bottle [7]. In this study, 4 L Van Dorn water sampler was used to collect the water samples. Van Dorn sampler was selected as it is the latest design of water sampler, reliable and made of transparent acrylic [8], thus the water sample inside is clearly visible during the sampling process. Samples were collected no closer than 30 cm to the surface water at each station. All water samples were stored in an icebox to maintain its condition. When arrived at the laboratory, the bottles were transferred into the freezer to reduce biological activity until the analyses were completed.

Quantitative and qualitative sampling techniques were used to collect zooplankton samples. [9] state that qualitative sampling involves vertical plankton net tows: by lowering the plankton net and towing it gently in a vertical direction to obtain zooplankton samples throughout the water column. A quantitative sampling was performed by filtering 40 L of lake water for each sample using the Wisconsin plankton net of 35 μm mesh size. The filtrate was transferred into 120 ml sample bottles and three sample replicates were collected at each station.

The parameters which were measured in-situ including water temperature, conductivity, total dissolved solid (TDS), pH and dissolved oxygen (DO) were measured using YSI Multiparameter (Model 556 MPS). The depth of the water was measured using Depthmate portable sounder while water transparency was measured using Secchi disc and measuring tape. Garmin GPS was used to locate the exact position of each sampling station.

2.3. Laboratory Analyses
In the laboratory, the physicochemical parameters were analyzed using methods from literatures. The concentration of nitrite-nitrogen (NO₂⁻-N), nitrate-nitrogen (NO₃⁻-N), ammonium-nitrogen (NH₄⁺-N), chlorophyll a and total suspended solid (TSS) were determined using the method from [10] while total phosphorus (TP) was analyzed following [11].

Zooplankton identification was carried out using a compound microscope (Olympus BX41) equipped with a camera and connected to the computer. The sample bottle was shaken gently and 1 ml of the sub-sample was randomly taken from the bottle by using an adjustable volume pipette. The sub-sample was placed into a Sedgewick Rafter counting cell and slowly covered with a coverslip to avoid any air bubbles produced in the slide. The specimen was observed under the microscope at 20X, 40X and 100X magnifications. For a detail examination, each specimen was transferred on the slide and a drop of 10% glycerol-water mountant was added. This method is particularly satisfactory in avoiding distortion of the specimen and the glycerin gives more clarity and prevents the specimen from drying.
out [12]. All specimens were then identified by referring to the taxonomic keys and drawings in [12], [13] and [14].

2.4. Data analyses
Two-way ANOVA was performed using IBM SPSS Statistics Version 20 to determine the significant difference of water quality parameters and zooplankton community between months and stations during the sampling period. Ecological indices (Simpson, Shannon-Weiner, Margalef and Pielou) were calculated to acquire the diversity, richness and evenness of the zooplankton community in the study sites.

3. Results and Discussion
The mean results for physicochemical parameters (in-situ measurements and nutrients analyses) at each sampling stations are summarized in Table 1. The data collected were averaged to represent the water column at each station. Most of the physicochemical variables examined (p<0.05) showed a significant difference either in temporal (monthly) or spatial (across stations) values. Dissolved oxygen concentration was at the range of 5.47 ± 0.67 mg/L and 3.93 ± 1.94 mg/L. According to [15], excessive amounts of nutrients can lead to low levels of dissolved oxygen in the water. In the current study, the low measurement of dissolved oxygen was probably due to the increasing amount of nutrients in the water that flow into the reservoir from the nearby palm oil plantation. The increase in nutrient level will lead to high biological oxygen demand (BOD), causing the dissolved oxygen level to become low. Station 6 which is located near the water gate recorded the highest mean conductivity measurement. It is probably due to the water that was discharged through the gate during raining season (October to December) and might carry along sediments with a high level of inorganic pollutant which then increase the conductivity measurement.

The parameter of temperature varied considerably between sampling stations. The temperature trend in this study shows an increase from Station 1 to Station 4 and decrease from Station 5 to Station 6 during the sampling day. It was probably due to the sequence of sampling station which was conducted in the morning starting from Station 1 and ended at Station 6 in the evening. According to [16], water temperature influenced by weather, latitude, altitude, time, season, air movement, cloud cover and water depth.

The low water transparency measurement occurred in the sampling stations probably due to raining and run-off process from residential areas that contribute to the higher turbidity level. [17] demonstrated that the turbidity level can increase due to organic and inorganic wastes discharged, oil spills and pollutant from the boat. Thus, high turbidity level will decrease the transparency of water particularly at Station 1. Other than becoming a source of nutrients, tropical rivers also provide a sedimentary sink for nutrients to the lake [4]. In this case, the excess fertilizer from the oil palm plantation as well as municipal waste enter the water in Bukit Merah Reservoir and increase the turbidity. The same occurred with the measurement of TSS and TDS as the wastes from the residential area around the reservoir flow into the water through run-off and increase the value. According to [18], water movement, particularly from the river to the lakes, are primarily canalized and often not intercepted, so they have high energy for erosion and large sediment-loading. The use of fertilizers in oil palm plantation which contained acid or chemical ingredient might influence the pH value. The pH value was also affected by nitrification and denitrification process [19]. According to [20], organic acids, mineral acids and acidic salts in water will increase the acidity of the water. Those environmental factors might also contribute to the acidic measurement of pH at the sampling stations.

Phosphorus can enter the river through various ways including biological, hydrological and geological processes due to natural and human activities. In the present study, low measurement of TP occurred and consistent at all stations. [21] stated that rain is one of the transporting factors for phosphorus to enter the aquatic systems through runoff from an adjacent residential area. Ammonia from industries and residential sewage, animal waste and bacterial activity enter the aquatic ecosystem.
Table 1. Variation of water physicochemical parameters in Bukit Merah Reservoir during the study period.

| Parameters          | Mean ± SE       |
|---------------------|-----------------|
|                     | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 | Station 6 |
| **Physical**        |           |           |           |           |           |           |
| Temperature (˚C)    | 27.39 ± 1.13  | 28.93 ± 0.48 | 29.03 ± 0.50 | 29.12 ± 0.60 | 28.77 ± 0.49 | 27.78 ± 0.51 |
| Turbidity (NTU)     | 69.757 ± 15.34 | 19.257 ± 2.86 | 15.177 ± 2.25 | 20.423 ± 3.07 | 16.667 ± 1.35 | 28.700 ± 2.15 |
| TSS (mg l⁻¹)       | 0.034 ± 0.004  | 0.026 ± 0.006 | 0.012 ± 0.003 | 0.017 ± 0.005 | 0.009 ± 0.002 | 0.021 ± 0.003 |
| Transparency (cm)  | 53.23 ± 3.35   | 78.22 ± 5.25 | 81.00 ± 4.65 | 76.90 ± 3.61 | 87.21 ± 5.82 | 61.33 ± 3.32 |
| **Chemical**        |           |           |           |           |           |           |
| DO (mg l⁻¹)        | 5.32 ± 0.13    | 4.51 ± 0.50 | 4.26 ± 0.06 | 4.56 ± 0.39 | 5.47 ± 0.67 | 3.93 ± 1.94 |
| Conductivity (µS cm⁻¹) | 27.67 ± 1.15 | 16.67 ± 1.53 | 17.33 ± 1.73 | 17.00 ± 1.73 | 25.67 ± 1.15 | 28.67 ± 2.08 |
| TDS (mg l⁻¹)       | 17.67 ± 1.53   | 10.33 ± 1.15 | 10.33 ± 0.58 | 10.33 ± 1.15 | 15.33 ± 0.58 | 17.67 ± 1.15 |
| pH                 | 6.34 ± 0.94    | 6.27 ± 1.05 | 5.63 ± 0.57 | 5.24 ± 0.49 | 5.70 ± 0.55 | 5.27 ± 1.15 |
| Chl. a (mg l⁻¹)    | 0.113 ± 0.0006 | 0.150 ± 0.0006 | 0.084 ± 0.0005 | 0.112 ± 0.0006 | 0.184 ± 0.0005 | 0.103 ± 0.0005 |
| TP (mg l⁻¹)        | 0.015 ± 0.0040 | 0.016 ± 0.0022 | 0.015 ± 0.0022 | 0.013 ± 0.0004 | 0.016 ± 0.0040 | 0.016 ± 0.0040 |
| NH₄-N (mg l⁻¹)     | 0.005 ± 0.0012 | 0.014 ± 0.0040 | 0.006 ± 0.0012 | 0.003 ± 0.0013 | 0.012 ± 0.0012 | 0.011 ± 0.0011 |
| NO₂-N (mg l⁻¹)     | 0.008 ± 0.0004 | 0.008 ± 0.0004 | 0.010 ± 0.0004 | 0.0012 ± 0.0003 | 0.009 ± 0.0003 | 0.009 ± 0.0003 |
| NO₃-N (mg l⁻¹)     | 0.080 ± 0.0062 | 0.035 ± 0.0066 | 0.022 ± 0.0062 | 0.019 ± 0.0038 | 0.041 ± 0.0043 | 0.059 ± 0.0052 |
[4] found out that the amount of nitrite and nitrate in Bukit Merah Reservoir are higher compared to ammonia. They also found out that nitrate and nitrite in sediment were maintained in the reservoir, but ammonia was delivered through the watergate. This present study agrees with their results that the amount of nitrite and nitrate were relatively higher than the amount of ammonia at most sampling stations.

In this current study, 49 taxa of zooplankton were recorded with 7 orders and 19 families (Table 2). Total of Rotifera taxa recorded was 34 followed by 13 species of Cladocera and 2 orders of Copepoda. The percentage of zooplankton species number by the group was illustrated in Figure 2. Rotifera was the dominant group with the highest species number recorded (69%) followed by Cladocera with 27% while Copepoda has the least number of species recorded (4%).

![Percentage of zooplankton composition species number by group in Bukit Merah Reservoir](image)

Mean zooplankton abundance at each station during the study period is shown in Figure 3. In October, Station 2 showed the highest zooplankton abundance with $37 \pm 6.00$ ind/L while the lowest abundance was from Station 4 with $6 \pm 1.76$ ind/L. In November, Station 3 showed the highest zooplankton abundance with $19 \pm 4.63$ ind/L while the lowest abundance was recorded in Station 6 ($4 \pm 1.20$ ind/L). Apart from that Station 5 recorded the highest zooplankton abundance in December ($18 \pm 2.31$ ind/L), the least number of zooplankton abundance was recorded in Station 4 ($4 \pm 1.86$ ind/L).

Zooplankton species composition can be affected by interacting with physical, chemical and biological components in both limnetic and littoral regions [22]. Other than that, zooplankton can be ideal indicators of an aquatic ecosystem as they are very sensitive to [23]. While dissolved oxygen was an important factor that will determine the distribution and abundance of zooplankton, Station 6 with the lowest mean of dissolved oxygen has also recorded the lowest mean of zooplankton abundance (Figure 3).

Zooplankton was inversely associated with conductivity [24]. In the current study, the station with the lowest zooplankton abundance recorded the highest mean value of conductivity. [25] also found that there is a strong association between conductivity and zooplankton taxa. [26] also found the result that agreed to the current study. TDS is another factor that affected the distribution and abundance of zooplankton in reservoirs. In this study, the mean abundance of zooplankton was inversely proportional to the mean value of TDS. [27] discovered that the number of zooplankton species decreases as TDS value increase, which is consistent with the current study. [28] also found that there was a negative correlation between TDS and zooplankton abundance.
| Group     | Order         | Family         | Species            | Taxa | Sampling Stations |
|-----------|---------------|----------------|--------------------|------|-------------------|
| Rotifera  | Bdelloidea    | Collotheceida  | Collotheca pelagica| +    | St. 1             |
|           |               |                | Collothea sp.      | +    | St. 2             |
| Flosculariacea | Colochilida   |                | Conochilus sp.     | +    | St. 3             |
|           |               | Testudinellida | Testudinella sp.   | +    | St. 4             |
|           | Filinida      |                | Filinia camasecla  | +    | St. 5             |
|           |               |                | Filinia sp.        | -    | St. 6             |
|           | Hexarthridae  |                | Hexarthra sp.      | +    |                   |
|           | Ploimida      | Asplanchnida   | Asplanchna sp.     | -    |                   |
|           | Brachionida   |                | Anuraeopsis coelata| -    |                   |
|           |               |                | Anuraeopsis fissa  | +    |                   |
|           |               |                | Brachionus falcatus| +    |                   |
|           |               |                | Brachionus quadridentatus| +   |                   |
|           |               |                | Brachionus quadridentatus mirabilis| -  |                   |
|           |               |                | Brachionus sp.     | +    |                   |
|           |               |                | Branchinus nilsoni | +    |                   |
|           |               |                | Keratella cochlearis| +   |                   |
|           |               |                | Keratella lenzi    | +    |                   |
|           |               |                | Keratella procupa  | -    |                   |
|           |               |                | Keratella serrulata| +    |                   |
|           |               |                | Keratella sp.      | +    |                   |
|           |               |                | Keratella tropica  | -    |                   |
|           | Gastropodida  |                | Ascomorpha sp.     | +    |                   |
|           |               |                | Gastropus sp.      | +    |                   |
|           | Lecanida      |                | Lecane signifera   | -    |                   |
|           |               |                | Lecane sp.         | -    |                   |
| Group         | Order       | Family       | Species                | St. 1 | St. 2 | St. 3 | St. 4 | St. 5 | St. 6 |
|--------------|-------------|--------------|------------------------|-------|-------|-------|-------|-------|-------|
| Rotifera     | Ploimida    | Lepadellida  | Lepadella sp.          | -     | -     | +     | -     | -     | -     |
|              |             | Mytilinidae  | Mytilina sp.           | -     | +     | -     | -     | -     | -     |
|              |             | Notommatida  | Cephalodella sp.       | -     | +     | +     | -     | -     | -     |
|              |             |              | Notomnata sp.          | -     | +     | +     | -     | -     | -     |
|              |             | Synchaetida  | Polyarthra sp.         | +     | +     | +     | -     | -     | -     |
|              |             | Synchaeta    |                        | -     | +     | -     | -     | -     | -     |
|              |             | Trichocerida | Trichocerca pusilla    | -     | +     | +     | -     | -     | -     |
|              |             | Trichocerca  |                        | +     | +     | +     | +     | +     | +     |
|              |             |              |                        |       |       |       |       |       |       |
| Cladocera    |             | Bosminidae   | Bosmina longirostris   | +     | +     | +     | -     | +     | +     |
|              |             | Bosmina sp.  |                        | -     | -     | -     | -     | +     | -     |
|              |             | Bosminopsis  | deitersi               | +     | +     | +     | +     | +     | +     |
|              |             | Daphniidae   | Ceriodaphnia cornuta   | -     | +     | -     | +     | +     | +     |
|              |             | Ceriodaphnia | sp.                   | -     | +     | +     | +     | +     | +     |
|              |             | Daphnia sp.  |                        | +     | -     | -     | +     | -     | -     |
|              |             | Moinidae     | Moina micrura         | -     | -     | -     | +     | -     | -     |
|              |             | Macrothricida| Macrothrix sp.         | +     | -     | -     | -     | -     | -     |
|              |             | Sididae      | Diaphanosoma aspinosum | +     | +     | +     | -     | +     | +     |
|              |             |              | Diaphanosoma excisum   | -     | -     | -     | -     | +     | -     |
|              |             |              | Diaphanosoma modigliani| -     | -     | -     | -     | +     | -     |
|              |             |              | Diaphanosoma sarsi     | -     | +     | +     | +     | +     | +     |
|              |             |              | Diaphanosoma sp.       | +     | +     | +     | +     | +     | +     |
| Copepoda     | Calanoida   |              |                        |       |       |       |       |       |       |
|              | Cyclopoidea |              |                        |       |       |       |       |       |       |

Total taxa = 49

(Notes: ‘+’ = Present, ‘-’ = Absent)
Figure 3. Mean zooplankton abundance in Bukit Merah Reservoir during the study period.

According to [29], 68 species of zooplankton have been recorded in two man-made lakes of Pantai Kamloon. The number was slightly higher than this present study. It is most probably because of the difference in the lake’s zone of sampling location in both studies. The sampling stations of both Lake A and Lake B in Pantai Kamloon were conducted at the littoral zone [29]. Meanwhile, the study at Bukit Merah Reservoir was done in both littoral and limnetic zone of the lake. [30] and [31] reported that the zooplankton species were higher in the littoral zone with a total of 120 and 67 species of zooplankton respectively. In the current study, Station 2, 3, and 4 were located in the littoral zone. However, the total species number and abundance was low in Station 4 most probably due to high water current at that particular station. Wastewater from the nearby village flows into the lake through the pipes that were situated nearby Station 4, creating the water movement all the time.

Few studies on freshwater zooplankton have been conducted in other tropical countries such as Brazil and sub-tropical countries such as India. For example, [32] investigated zooplankton distribution in Lake Dome Helvicio, Brazil and recorded 184 species in the littoral zone with aquatic vegetation and 117 species in the littoral zone without the aquatic vegetation. [33] conducted research in a tropical floodplain of the Brahmaputra river basin, Assam (Northeast India). They found 143 species of zooplankton collected from the littoral and semi-limnetic stations. Their finding was higher than the current study probably because of the size of the lake which is bigger than Bukit Merah Reservoir and due to a longer sampling period. Zooplankton respond quickly to changes temporally in their habitat and their abundance can increase on the time scales of days to months [34, 35].

Rotifera was the most dominant group of zooplankton recorded in Bukit Merah Reservoir. The total number of species was 36, making up the highest percentage of species number which was 69%. Brachionidae family was the most diverse family of Rotifera with 13 species of zooplankton. [36] stated that in a freshwater pond of Noakhali District, Bangladesh, Rotifera occurred as the most dominant species. 38% of Rotifera was found in culture pond, 37% was found in the household pond and 53% was recorded in an unused pond.

Cladocera are small crustaceans that are distinguished by a two-valve carapace, or outer shell, shielding most of their body [37]. Daphnia, Bosmina, Ceriodaphnia, and Diaphanosoma are example genera of this group which seem very similar except for very small distinctions in their body shape. Cladocera were recorded with 13 species in Bukit Merah Reservoir which were Bosminopsis longirostris, Bosmina sp., Bosminopsis deitersi, Ceriodaphnia cornuta, Ceriodaphnia sp., Daphnia sp.,
The abundance of zooplankton in the six sampling stations was not uniform. Station 3 recorded the highest number of zooplankton abundance which is 212 ind/L while the lowest was recorded in Station 6 with 48 ind/L. Analyses of ANOVA shows that there was a significant difference of zooplankton abundance between sampling station (p=0.03) and also a significant difference of zooplankton species number between sampling station (p=0.001). As stated by [38], the main planktonic group of zooplankton (Rotifera, Cladocera and Copepoda) compete for a common food resource. Moreover, most copepod species feed on Cladocera and Rotifera as they possess the ability of efficient predators. Hence, the inconsistency of zooplankton abundance in the sampling stations was probably owing to the interspecific competition and also the prey-predation relationship of the main zooplankton groups. The interspecific competition or interaction with individuals of other zooplankton species has been reported as the pivotal component in structuring zooplankton communities [39] while the prey-predation relationship is known to significantly influence the structure of zooplankton population [40]. Both factors govern zooplankton feeding and reproduction subsequently responsible in shaping zooplankton communities in the aquatic ecosystem.

The ecological indices for zooplankton abundance were presented in Table 3. In the current study, Diversity, Evenness and Richness Indices were calculated. According to [41], the Simpson Index is used to measure the probability that two randomly chosen individuals belong to different species. A high value of the index indicated that the probability of choosing different species is high. Thus, it shows that Station 6 which has the lowest value of Simpson’s Index has the highest possibility to select the same species. Margalef Index is the indicator of the richness of the species in a community. Station 4 has the lowest value of Margalef Index, which indicates that the number of species in Station 4 is the lowest. [42] suggested that Pielou Index is used to study the evenness or randomness of the abundance in a population. The analyses for Pielou Index show that the value is near to 1 in all sampling station. Hence, there was less variation between the species of each station and the zooplankton species was distributed evenly.

### Table 3. Ecological indices of zooplankton at all stations in Bukit Merah Reservoir.

| Station | Diversity Indices | Richness Indices | Evenness Indices |
|---------|-------------------|------------------|-----------------|
|         | Simpson Index (D) | Shannon-Weiner Index (H') | Margalef Index (R) | Pielou Index (J') |
| 1       | 0.83              | 2.56             | 5.28            | 1.15             |
| 2       | 0.86              | 2.7              | 5.28            | 1.17             |
| 3       | 0.91              | 2.39             | 3.98            | 1                |
| 4       | 0.79              | 1.98             | 2.71            | 1.12             |
| 5       | 0.88              | 2.02             | 3.06            | 0.95             |
| 6       | 0.71              | 2.25             | 3.73            | 1.29             |

### 4. Conclusion

The dominant group of zooplankton with the highest abundance was Rotifera and Brachionidae was the most diverse family. Station 3 recorded the highest zooplankton abundance of 212 ind/L. Analyses of variance show that there was a significant difference in zooplankton abundance and species number between station (p<0.05). Overall, physicochemical parameters and zooplankton biodiversity indicated variations at each sampling stations. The distribution and abundance of zooplankton were greatly influenced by the area of sampling station and the ecological condition of the reservoir. Domestic waste, runoff from the residential area and oil palm plantation are some of the treats to Bukit Merah Reservoir.
Several problems encountered by Bukit Merah Reservoir are believed to be caused by anthropogenic activities from upstream and surrounding area of the reservoir. Therefore, long term monitoring of water quality and assessment strategies must be conducted for the lake’s sustainability and future generations.

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