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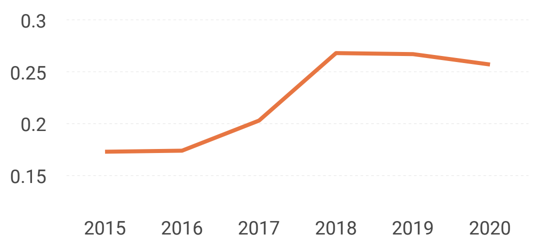

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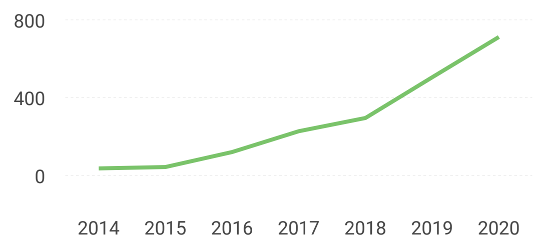

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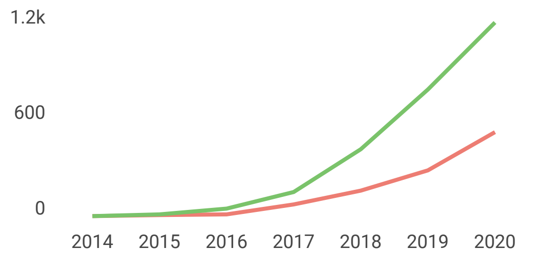

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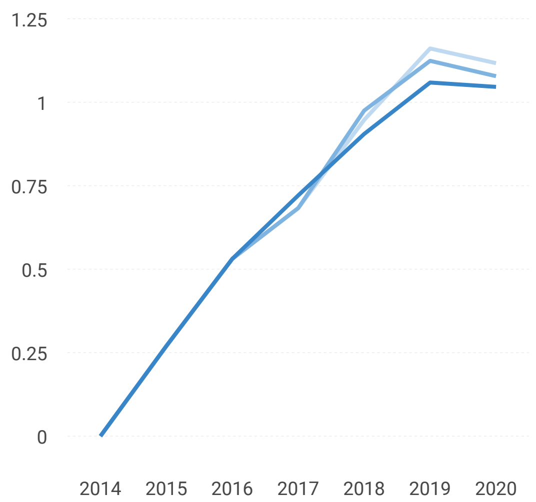

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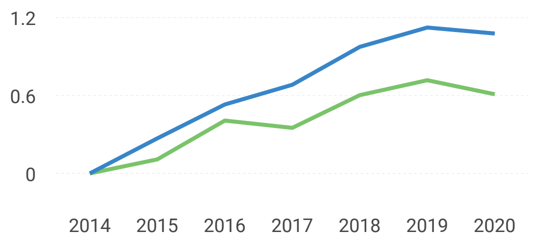

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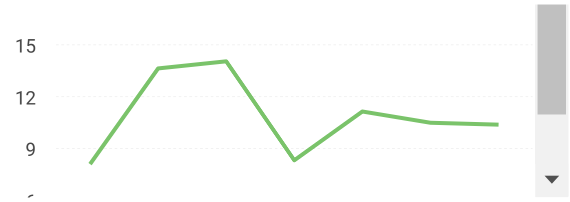

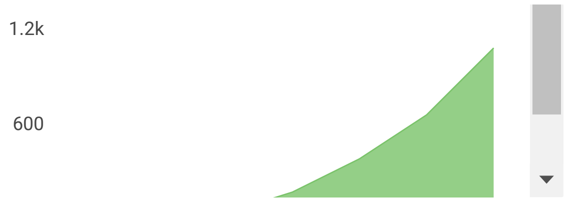

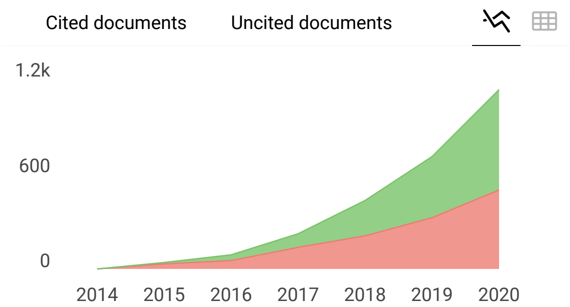

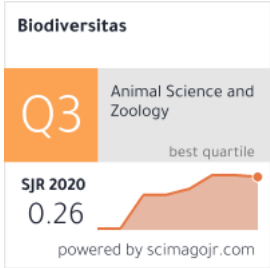

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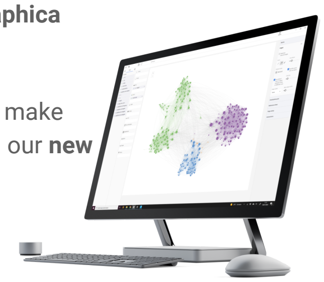

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Short Communication: Benthic macroinvertebrate diversity as biomonitoring of organic pollutions of river ecosystems in Central Java, Indonesia

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Abstract. *Wibowo DN, Setijanto, Santoso S. 2017. Short Communication: Benthic macroinvertebrate diversity as biomonitoring of organic pollutions of river ecosystems in Central Java, Indonesia. Biodiversitas 18: 671-676.* Benthic macroinvertebrates are mainly aquatic insects that spend most of their lives in the freshwater ecosystems. The physical, chemical, and biological conditions of rivers have a direct influence towards aquatic insects (Ephemeroptera, Plecoptera, and Trichoptera EPT) which make them good indicators of stream water quality. We examined the use of benthic macroinvertebrates diversity as a biomonitoring tool to assess organic pollution levels in three rivers in Purwokerto city during March to October 2011. Our objective was to test the sensitivity of benthic macroinvertebrates especially Ephemeroptera, Plecoptera, and Trichoptera (EPT) diversity to organic pollution levels reflected by biological oxygen demand (BOD) concentrations. A total of 27 sites with different BOD levels were surveyed in three different rivers (Logawa, Banjaran, and Pelus) during the period of March to October 2011. The results revealed no correlation of benthic macroinvertebrate diversity (EPT index) to BOD levels. It could be concluded that in the use of EPT index as bioindicators of waters condition, the number of samples, sampling time, and location should be considered.

Keywords: Benthic macroinvertebrates, biomonitoring, diversity, organic pollution

INTRODUCTION

Purwokerto is a medium town and capital of Banyumas District. It is geographically located at Southwest of Central Java Province, Indonesia. Settlement growth of this town was very high resulting in the high conversion of open area or green space area into settlement area. This condition leads to the elevation of organic waste product disposal on the rivers crossing this town. Three rivers flows through the city are Pelus in the East, Banjaran in the Middle, and Logawa in West part of the city (Figure 1). Those rivers are suspected of having contamination of organic materials derived from household waste (Wibowo and Setijanto 2011). These activities have imposed stress on flowing water ecosystems (Ellias et al. 2014). It is unlikely that there is a substantial number of freshwater bodies remaining that have not been irreversibly altered from their original state as a result of anthropogenic activities (Selvanayagam and Abril 2014).

Aquatic macroinvertebrates or benthic macro-invertebrates are mainly aquatic insects that spend most of their lives in the freshwater ecosystems. Aquatic insects are found ubiquitous in stream ecosystems, and present throughout a wide range of environmental conditions which make them a successful and appropriate model group for investigation at different levels of the process, including at the individual, populational, and also community level (Heino and Peckarsky 2014). At multiple spaces (spatial) and time (temporal) scales, the variation in the structure and organization of the aquatic insect communities are greatly influenced by abiotic environmental conditions, biotic conditions, and dispersal processes (Malmqvist 2002; Heino et al. 2003). The physical, chemical, and biological conditions of streams have a direct influence towards aquatic insects which make them good indicators for stream water quality (Budin et al. 2007; Gerami et al. 2016; Kalyoncu and Zeybek 2011). The three major orders of aquatic insects that can be found abundantly in freshwater systems are Ephemeroptera, Plecoptera, and Trichoptera (EPT) (Corona 2010). EPT is considered as an essential taxonomic group due to its wide range of distribution with high abundance and species richness (Righi-Cavallaro et al. 2010). According to Bispo and Oliveira (2007), EPT makes up a rich collection of taxa in low and medium order streams which occur primarily in clean and well-oxygenated water. The diversity and composition of EPT which functions as indicator species make them possible to determine the status of aquatic system water quality (Che Salmah et al. 2001). EPT is highly sensitive towards any anthropogenic and environmental disturbances which allow them to become excellent indicators in evaluating and accessing the water quality of streams (Corona 2010; Myers et al. 2011). Thus, EPT can be considered as the key aquatic insect orders as they play vital roles in the aquatic ecosystems.

There is not much in the database of EPT in Indonesia as compared to temperate regions. According to Susheela et al. (2014), aquatic insects are usually overlooked and unfamiliar to the public. Because EPT has not been widely examined in Indonesia ecological studies, this study could provide baseline data for the records of EPT in Indonesia, especially in Purwokerto. In tropical regions, previous research had been done by Arman (2004) and Wahizatul et al. (2011) in rivers in Malaysia. This study is expected to provide more information for future research regarding the composition and distribution of EPT communities in tropical rivers. Apart from that, EPT has been used to evaluate the water quality of freshwater ecosystems as EPT is highly specific to environmental stressors, such as temperature, anthropogenic disturbances, and pollutions (Corona 2010).

Monitoring water quality by biological approaches especially using EPT index has greater advantages compared to physicochemical approaches, which are expensive and require specialized equipment, and also biological approaches provide better water quality predictions (Wibowo and Setijanto 2011; Jun et al. 2012). The measurement of biological parameters enables long-term prediction of organic pollution levels, whereas physicochemical measurement provides only short-term predictions. Biological changes can be monitored by analyzing structural changes in groups of benthic macroinvertebrates in the river environment. If the river has a polluted or damaged habitat, a decline in species richness and the diversity index will happen, and more tolerant species will become dominant (Flores and Zafalara 2012).

In Banyumas regions, rivers are usually polluted by organic pollutant coming from surrounding area. The signs of organic pollution were variety of biological oxygen demand (BOD), total suspended solid (TSS), and turbidity value. BOD is the amount of oxygen needed by bacteria to decompose almost all suspended and dissolved organic matter in the water. Waters experiencing environmental stress due to organic contaminants have low BOD values. The spatiotemporal change of water quality parameters such as BOD could be attributed to the different concentration of organic matter, within a water body at a given point in time influenced the composition and distribution of macroinvertebrates. The predators were found to be highly associated with the elevated concentrations of BOD (Ngodhe et al. 2014). Ishadi et al. (2014) found that BOD has a negative impact on insect macroinvertebrates (EPT) diversity in Kerian Basin River, Perak, Malaysia. It means that BOD can be used as environmental parameters of rivers pollutions.

Information about the relationships between benthic macroinvertebrates especially EPT and organic pollution levels in Indonesia is rare. Therefore, it is important to apply these biological approaches to water quality monitoring in aquatic ecosystems. Thus the objective of this research was to determine any changes in the insect benthic macroinvertebrate community (Ephemeroptera, Plecoptera, and Trichoptera) in response to change in water quality (BOD) in 3 rivers in Purwokerto regions during the study period.

MATERIALS AND METHODS

Study site

The research has been done on three rivers in Banyumas regions (Banjaran, Pelus, and Logawa), during March-November 2011. Locations and habitat description were showed in Figure 1 and Table 1.

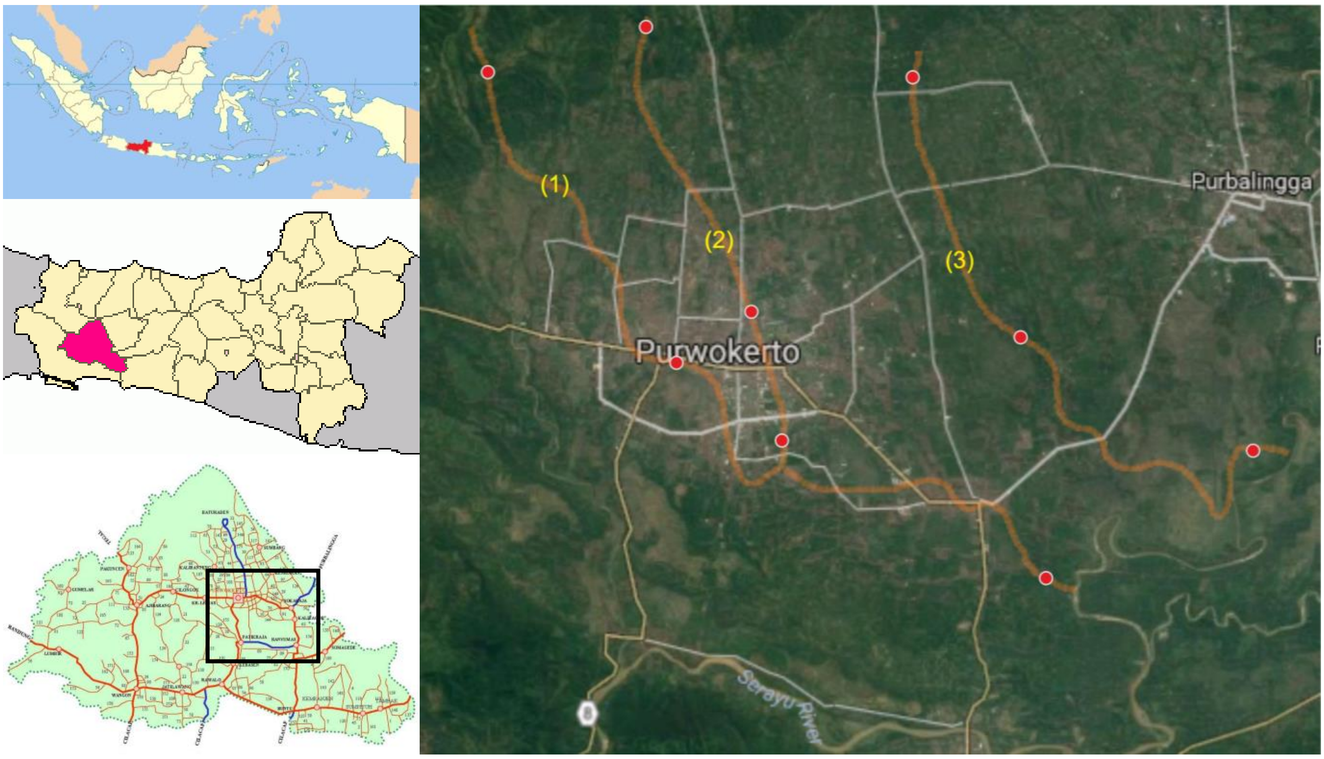

Figure 1. Study site in Purwokerto, Central Java, Indonesia, left to right: Logawa River (1), Banjaran River (2), and Pelus River (3)

Table 1. Habitat description of three rivers in Purwokerto, Central Java, Indonesia

Rivers	Location	Latitude	Substrate	Landuse
Logawa	Sunyalangu	7º23’08.7”S, 109º11’21.51”E	Stone	Forest, agriculture
	Sidabowa	7º27’5.21”S, 109º12’8.32”E	Stone	Agriculture, settlement
	Patikraja	7º29’3.02”S, 109º13’1.36”E	Stone, mud	Agriculture, settlement
Banjaran	Curug Gede	7º19’34.55”S, 109º13’14.49”E	Stone	Forest, agriculture
	Beji	7º23’40.65” S, 109º12’32.12”E	Stone	Agriculture, settlement
	Bantarsoka	7º25’25.27”S, 109º13’19.17”E	Stone, mud	Settlement
Pelus	Kemutug	7º40’1.17”S, 109º14’5.24”E	Stone	Tourist area
	Pajerukan	7º28’3.65”S, 109º18’9.35”E	Mud	Agriculture, settlement
	Jatikoreh	7º38’7.95”S, 109º19’1.86”E	Mud	Agriculture, settlement

Sampling method

Benthic Macroinvertebrate was sampled from 27 locations with random distribution at the three rivers. Each sampling was done in 3 locations of upstream, 3 locations of the middle stream, and 3 locations of downstream to get the reflection of organic pollutions level. Benthic macroinvertebrates were collected using Surber nets and extrapolated to total individuals/m^2. It was assumed that such a wide region of the survey could cover the majority of stream types in Banyumas to understand how macroinvertebrates are spatially distributed about environmental factors. Organic pollution was measured by BOD level. Species identification was performed at the Fishery and Marine Department Laboratory in the Faculty of Sciences and Technology and the Aquatic Biology Laboratory and Ecology Laboratory in the Faculty of Biology, Universitas Jenderal Soedirman, Purwokerto, Central Java, Indonesia.

Data analysis

Benthic macroinvertebrates diversity was calculated using Shannon-Wiener with the help of BD Pro 2 software. To assess the sensitivity of macroinvertebrates (EPT) diversity as bioindicators of water quality, the correlations of H-index with BOD levels were calculated, and the sensitivity of each approach was defined based on the resulting R-square value. The EPT index was calculated following the procedure of Shannon-Wiener Diversity Index (H’) and the evenness (H max) was calculated using PAST software.

RESULTS AND DISCUSSION

Species richness and abundance

A total of 2,787 specimens were collected at 27 sampling stations during the survey, consisting of 11 order of macrobenthos, 9 orders (86.6%) of class Insecta and the rest is of Annelida and Mollusca (both 14.6%) (Figure 2). The insecta consists of orders of Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Neuroptera, Diptera, Hemiptera, Zygoptera, and Megaloptera. In total, species of Ephemeroptera and Plecoptera was very dominant (26.8%), followed by Plecoptera (17.39%) and Coleoptera (10.1%). This finding was in line with Wahizatul et al. (2014) who have done research at Trengganu, Malysia and Leba et al. (2013) at Pajowa River North Sulawesi.

In our study site, orders Ephemeroptera, Plecoptera, Trichoptera, and Coleoptera are found at all part of three rivers (upstream, middle stream, and downstream). These results suggest that all rivers are still in good condition or clean (Wahizatul et al. 2013). Correlation analysis of physichochemical factors showed no significant correlation (r^2 = 0.036). Significant changes in macroinvertebrate horde were primarily due to changes in water quality (Sharma and Chowdhary 2011; Mustapha and Yakubu 2015). In this study, water quality has no significant different in the sampling sites with that in the rivers ($F_{3.27}$ = 1.07, p = 0.669).

A number of species in river showed no significant difference. The highest species richness in Logawa river is found in station I (upstream) and station II (middle stream) with seven species, and only five species are found in downstream. In Banjaran River, the highest species richness is in middle stream with six species and five species are found in upstream and downstream. In Pelus rivers, only five species are found in upstream and middle stream and 4 species are found in downstream (Figure 3). According to Jun et al. (2016), macroinvertebrate diversity and abundance are significantly influenced by physical factors such as substrate composition, velocity, elevation and size of stream and temperature. This study suggested that substrate composition of upstream, middle stream, and downstream were not different.

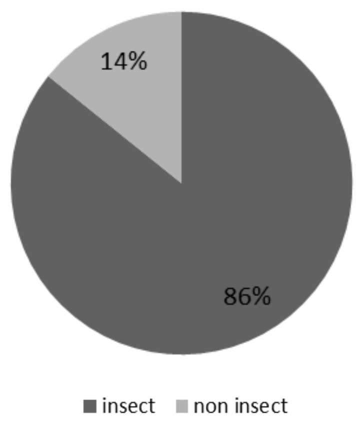

Figure 2. Order composition of benthic macroinvertebrate in three rivers in Purwokerto, Central Java, Indonesia

Table 2. Macrobenthic orders in three rivers in Purwokerto, Central Java, Indonesia

Orders	Location								
	Logawa			Banjaran			Pelus		
	Replication			Replication			Replication		
	I	II	III	I	II	III	I	II	III
Benthic macroinvertebrate									
Ephemeroptera	2	2	2	3	1	1	3	1	3
Plecoptera	5	5	0	2	1	1	1	1	2
Trichoptera	2	2	0	0	1	1	0	1	0
Coleoptera	2	2	0	2	1	1	2	0	2
Neuroptera	1	1	2	0	0	1	0	0	0
Diptera	0	0	0	2	0	0	0	3	0
Hemiptera	0	0	1	0	0	0	0	0	0
Zygoptera	0	0	0	0	0	0	1	0	0
Megaloptera	1	1	0	0	0	0	0	0	0
Gastropoda	2	2	2	1	1	0	2	1	2
Annelida	0	0	2	0	2	0	0	0	0
Individual	15	15	9	10	7	5	9	7	9
Species	7	7	5	5	6	5	5	5	4
Environmental factors									
BOD	0.8	3.8	4.2	0.4	2	6.6	2.1	2.8	3.2
Turbidity	0.91	3.7	9.3	6.2	6.7	9.9	0.42	2.2	6.5
TSS	43	56	63	37	79	88	12	14	29
EPT index	9	9	2	5	3	3	4	3	5

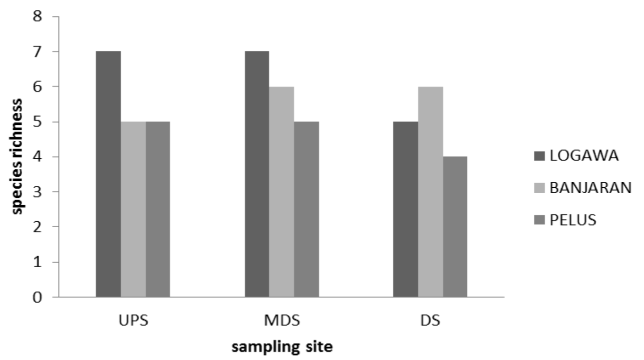

Figure 3. Macrobenthic species richness from sampling stations in three different rivers in Purwokerto, Central Java, Indonesia

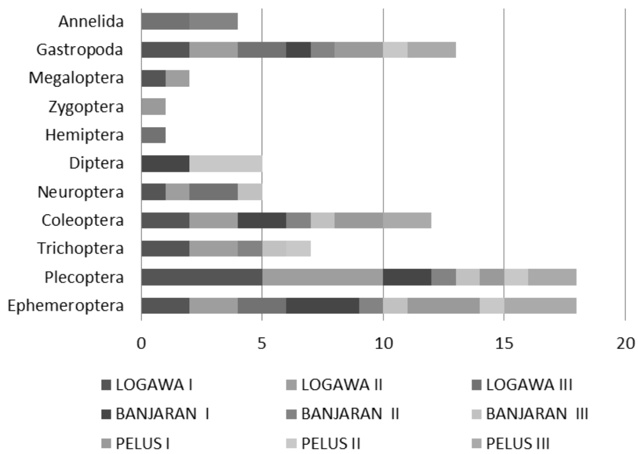

Figure 4. Dispersal of macroinvertebrates order within and between rivers in Purwokerto, Central Java, Indonesia

The distribution of benthic macroinvertebrates is influenced by the interaction of habits, physicochemical variables, structural and hydrological characteristics, and by human activities (Romero et al. 2013). Dispersal of aquatic insect communities is an essential process which influences the river's conditions. Therefore, changes in characteristics, habitat and environmental resources of rivers can strongly influence patterns of spatial and temporal distribution in benthic communities (Buss et al. 2004; Silveira et al. 2006). Our result showed that orders Ephemeroptera, Plecoptera, Trichoptera, and Coleoptera were found in all three rivers. Neuroptera was only found in Logawa and Banjaran rivers, while Hemiptera and Megaloptera were only found in Logawa river, Zygoptera was only found in Pelus River. Ephemeroptera, Plecoptera, Trichoptera, and Coleoptera were found in all parts of these rivers. Diptera was found in upstream of Banjaran river and middle stream of Pelus River. Megaloptera was found in upstream and downstream of Logawa River and Hemiptera was found only once in downstream of Logawa river

(Figure 4). These results showed that benthic macroinvertebrates from insect orders have random distributions along the rivers except four orders. Aquatic insects have complex life cycles with distinct developmental stages that differ in their requirements to use aquatic and terrestrial habitats. Aquatic insects generally have an immature stage confined to living, feeding, and dispersing (e.g. drift or crawling) in the aquatic environment. Adult stages for most aquatic insect taxa are terrestrial. Instream dispersal is possible by crawling, swimming, and drift during the aquatic stage (Smith et al. 2009). Thus condition may affect the result of this research.

The consistent dispersal of the macroinvertebrates in three rivers in Purwokerto resulted in a very low EPT index. In theory, the presence or absence of macroinvertebrates in any given freshwater ecosystem is a function of habitat quality, physicochemical parameters, and the regional taxonomic pool (Suleiman and Abdullahi 2011). Consequently, a wide variety of freshwater habitat and water chemistry offers the potential for a high diversity of freshwater macroinvertebrates (Sharma and Chowdhury 2011). Macroinvertebrate communities at degraded sites are characterized by either absence of any sensitive taxa or presence of few if any; greater dominance of only a few taxa; and larger numbers of macroinvertebrates that are tolerant to pollution (Ellias et al. 2014). Indeed, no relationship between the orders found and the degradation of the water courses appears to support such contention. Orders Ephemeroptera, Plecoptera, and Trichoptera can still be found in impacted sites in Logawa, Banjaran, and Pelus rivers. In conclusion, these results suggest that their potential use of macroinvertebrates diversity, especially Ephemeroptera, Plecoptera, and Trichoptera (EPT index) as key indicators of water quality assessment for biomonitoring programs, in this study, is still questionable. This inconsistent result may be affected by some factors such as numbers of the sample, sampling site, and time of sampling.

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