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Aquatic Insect Community as Indicator of Water Quality Assessment in Situ Gede System, Bogor, Indonesia

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Abstract. Aquatic insects have important role in food web and can be used as bio-indicators in aquatic ecosystems. Each aquatic insect has different tolerance value to environment condition in which only few species can survive in polluted ecosystems. Thus, lakes condition can be evaluated by using aquatic insects. One of purpose of this study is to assess the water quality in four situ using aquatic insects community as biotic index. Insects and abiotic data were sampled once a month for five months (January, February, March, June, and July 2016) in Situ Gede Systems including Situ Gede (SG), Situ Panjang (SP) and Situ Burung (SB), compare with Situ LSI (SL) as an excluding the system. Twelve sampling points of littoral zone were selected in each situ. Insects were captured by filtering fifty-liter water of situ using net with 50 µm mesh size. Abiotic factors such as pH, temperature, DO, and turbidity of water measured at each situ. During the study period, aquatic insect community was represented by a total 598 individual from 14 families. Corixidae and Notonectidae were the most dominant family in all situ. Based on Hilsenhoff Biotic Index (HBI), all situ were fairly contaminated by organic compound.

Keywords: Corixidae, Notonectidae, Situ Gede, Biotic index

1. Introduction

Aquatic insects are one of the important components for food web in freshwater ecosystems [1,2]. In the food web of lake ecosystem, aquatic insects are the main prey of nekton and have role as decomposer of organic matter [1,2]. Therefore, aquatic insects can be used as a bioindicator of ecosystem stability and water quality [3,4].

Level of pollution from human waste in aquatic ecosystem can be detected by assessing abiotic or biotic water quality parameters. High level of pollution can create shallow lakes and decrease biodiversity in aquatic ecosystem and deteriorate of ecosystem services [5]. Abiotic factors such as temperature, pH, dissolved oxygen (DO), nitrite and nitrate concentration are usually used directly to detect the contamination in that sampling period [6]. Meanwhile, biotic factors such as macro invertebrates especially aquatic insects as biotic index for water quality assessments can represent the long period condition of aquatic ecosystems due to their long exposure in aquatic ecosystem [7].

Biotic index is an indicator to evaluate and monitor water quality in river and lakes [7]. Hilsenhoff [8] develop the biotic index to determine the tolerant value from all aquatic invertebrates. The level of contaminant can be detected by observing changes in the aquatic invertebrates, which have naturally inhabited the area. Biotic index measurement had been conducted that indicate the organic



pollution level in aquatic ecosystems. Each family of aquatic invertebrates has different score, which describe the organic pollutant.

Research had already been conducted about aquatic insects from different aquatic habitats in Indonesia [9-12]. However, researches on aquatic insects were mostly conducted in riverine ecosystems [10,13-15] and only one research used them as bioindicator [15]. Few aquatic insect researches were done in lakes such as in natural lakes and artificial lakes [11-12]. Lakes condition can be evaluated by using aquatic insects, that inhabit under or on top thin layer of surface water, as biotic index. The aquatic insects as biotic index for water quality assessment in lakes are still rarely researched and documented, although lakes are important for watering system such as drinking, agriculture and industry [16-17]. Therefore, the aims of this study are: 1) to compare the aquatic insect community among four situ in Bogor, Indonesia and 2) to assess the water quality in Situ Gede systems using aquatic insects community as biotic index.

2. Study sites and methods

2.1. Study sites

The sampling sites were pointed in four situ within Bogor, Indonesia, which are Situ Gede (SG), Situ Panjang (SP), Situ Burung (SB) and Situ LSI (SL). The water from SG, SP and SB flows into Cisadane river and become Situ Gede Systems. Priawandiputra [17] described characteristics and conditions in each situ of Situ Gede systems. Meanwhile, SL is out of Situ Gede System and located inside Bogor Agricultural University Dramaga Campus, so the water flow is different with Situ Gede System. SL is managed by University and surrounded by building and some trees.

2.2. Sampling techniques

In each situ, twelve sampling sites were established for measurement of abiotic condition and aquatic insect collection. Abiotic data and aquatic insects were collected once a month for five months (January, February, March, June and July 2017). Temperatures, pH, depth and Dissolved Oxygen (DO) (LUTRON PDO-520) were measured in the sampling sites. Meanwhile, turbidity (T HACH 2100 Q) was determined in Probing Laboratory, Bogor Agricultural University and precipitation data was gathered from BMKG. Aquatic insects were sampled by filtering 50 L lake water using a net 50 µm mesh size in littoral areas. Collected aquatic insects were put into bottle filled with 70% alcohol and taken to Animals Biosystematics and Ecology Laboratory for identification and analysis. Aquatic insects were identified using insect identification books [18-20]. All aquatic insects were identified until family level.

2.3. Analysis

Data was analysed using descriptive statistics, Hilsenhoff Biotic Index (HBI) and analysis of insect communities composition. The descriptive statistics were calculated using average and standard deviation of abiotic data and sum for aquatic insect abundance. HBI was used to determine pollution level in lakes. HBI is calculated using Hilsenhoff formula [8], as below:

$$HBI = \frac{\sum ni \cdot ai}{N}$$

HBI : Hilsenhoff Biotic Index

ni : number of specimen in each taxon

ai : tolerance score for each group of taxon (Table 1)

N : number of individuals of insects in samples

Each family has different tolerance score, which indicate tolerant level of organism to organic pollutant in environment (table 1). Interpretation of HBI can be evaluated the water quality of situ, especially in organic pollution level (table 2). Clustered analysis and analysis of similarity (ANOSIM) with Bray Curtis index were used to analyze composition of aquatic insects among situ using *Paleontological Statistics* (PAST) ver. 1.89 [21].

Table 1. Tolerance score for families based on modification of Hilsenhoff [8]

Order	Family	Tolerance score
Diptera	Chironimidae	3.00
Ephemeroptera	Baetidae	1.00
	Caenidae	4.00
Hemiptera	Corixidae	2.00
	Gerridae	2.00
	Nepidae	2.00
Odonata	Lestidae	5.00
	Coenagrionidae	5.00
	Libellulidae	5.00

Tabel 2 Evaluation of water quality using modification of family-level biotic index for the Hilsenhoff *Biotic Index* (HBI)

Hilsenhoff <i>Biotic Index</i>	Water quality	Degree of organic pollution
0-1	Good	Possible slight organic pollution
2-3	Fair	Fairly substantial pollution likely
4-5	Poor	Very substantial pollution likely

3. Results

3.1 Abiotic Conditions

The four situ have various abiotic conditions in each month (Table 3). The high precipitation was obviously higher in February (610 mm) compared to other months. The low precipitation started from June to July. The depth in littoral area was always low in SP than other situ, which showed the shallow water. The range of water temperatures, pH and DO were 28-32°C, 5-7 and 5-6 mg/L, respectively. The turbidity has high range from 2-17 NTU where the highest turbidity was found at SP in January.

3.2 Abundance, Species Richness and Composition of Aquatic Insects

A total 598 individuals of aquatic insects were collected from 14 families, which were Corixidae, Gerridae, Hydrometridae, Notonectidae, Nepidae, Chironomidae, Lestidae, Baetidae, Formicidae, Acrididae, Chrysomelidae, Caenidae, Coenagrionidae, and Libellulidae (Table 4). Abundance of aquatic insects was high in SL (271 individuals), followed by SP (168 individuals), SB (87 individuals) and SG (72 individuals).

The highest number of individuals was from family Corixidae, especially in SL (223 individuals). The Corixidae were also the most abundant aquatic insect in total of all situ (440 individuals). It was followed with Notonectidae (63 individuals).

Both Corixidae and Notonectidae showed different patterns of abundance during five months sampling period (figure 2 and 3). Corixidae was mostly found in July at SP (figure 2b) and SL (figure 2d), while it was mostly found in June and March at SG (figure 2a) and SB (figure 2c), respectively. Notonectidae was only collected in SG and SP (figure 3). It was the dominant species in February and March at SP.

Table 3. The differences of abiotic conditions during study period among situ.

Months	Situ	Depth (m)	Temperatures (°C)	pH	DO (mg/L)	Turbidity (NTU)	Precipitation (mm)
January	SG	0.97±0.14	32±0.74	7±0	6±0.80	2±0.32	462
	SP	0.36±0.11	32±1.38	7±0.29	5±0.61	17±8.54	
	SB	0.50±0.23	29±1.60	7±0.52	6±0.63	8±1.90	
	SL	0.93±1.08	29±0.40	6±0.51	6±0.93	6±0.74	
February	SG	1.04±0.13	32±0.74	6±0.39	5±0.46	2±1.47	610
	SP	0.29±0.12	29±1.14	6±0.45	6±0.65	8±4.79	
	SB	0.42±0.12	29±2.35	6±0.39	6±0.54	9±2.54	
	SL	0.71±0.73	28±0.12	5±0.29	6±0.89	4±0.69	
March	SG	0.94±0.12	31±0.62	6±0.39	5±0.67	10±0.34	450
	SP	0.37 ±0.10	31±0.97	6±0.51	6±0.95	2±1.24	
	SB	0.43±0.07	30±2.11	7±0.49	6±0.55	5±1.54	
	SL	0.75±0.75	29±0.51	6±0	6±0.73	3±1.0	
June	SG	0.95±0.15	30±0.95	6±0.69	6±0.69	3±0.62	373
	SP	0.35±0.09	29±1.37	6±0	6±1.25	7±4.83	
	SB	0.47±0.14	32±0.39	6±0.39	6±0.49	2±0.88	
	SL	0.79±0.96	30±0.56	6±0	5±0.53	2±0.59	
July	SG	0.97±0.11	29±0.37	6±0	5±0.87	2±0.73	293
	SP	0.35±0.10	30±1.31	6±0	6±0.66	10±4.83	
	SB	0.51±0.13	29±0.37	6±0.45	6±0.65	3±0.94	
	SL	0.86±0.93	29±0.70	6±0	6±0.96	2±0.43	

Compositions of aquatic insects were not significantly different among four situ (ANOSIM, $p>0.05$). However, SL was formed into the different group cluster with others (figure 1). The results showed that the system of Situ Gede (SG, SP and SB) is the reason for the similar composition on aquatic insects.

Table 4. List Families of aquatic insects composition in all situ.

Order	Families	Number of individuals			
		SG	SP	SB	SL
Hemiptera	Corixidae	54	97	66	223
	Gerridae	0	3	0	5
	Hydrometridae	10	0	0	0
	Notonectidae	5	58	0	0
	Nepidae	0	1	1	7
Diptera	Chironomidae	0	4	11	28
Odonata	Lestidae	0	2	3	1
	Coenagrionidae	0	0	0	4
	Libellulidae	0	0	0	1
Ephemeroptera	Baetidae	0	2	4	0
	Caenidae	0	0	2	0
Hymenoptera	Formicidae	2	1	0	0
Orthoptera	Acrididae	0	0	0	1
Coleoptera	Chrysomelidae	1	0	0	0
Lepidoptera	Hesperidae	0	0	0	1
Total		72	168	87	271

3.3 Hilsenhoff Biotic Index (HBI)

Hilsenhoff Biotic Index (HBI) value presented in Table 5 where the values were quite similar among four situ from five months sampling. The range values every month in each situ were from 2 to 2.79. Meanwhile, average value from five month in each situ was from 2.00 to 2.23.

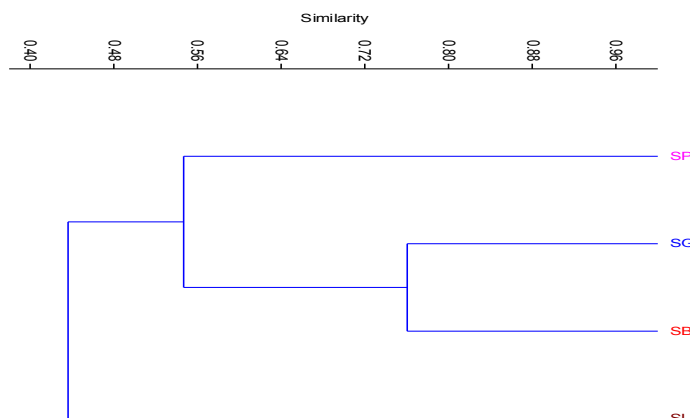


Figure 1. Clustering analysis of insect composition among four situ

4. Discussion

Abundance of aquatic insects was found to be high in SL (271) and SP (168). Meanwhile, in SG and SB, the total abundance of aquatic insects was less than 100 individuals. The different littoral condition among the situ was considered as one of the causative factor. Concrete structures were found less at the littoral zones of SL and SP compared to SG and SB. In SL and SP, only 4 sampling sites were situated on concrete. Concrete revetments reduced diversity of aquatic insects [22]. Aquatic insects prefer the littoral condition without concretes for their habitat because most aquatic plants were removed in littoral zone with concrete. Therefore, it could inhibit the activity of some aquatic insects where their use plants for foraging, refuge and oviposition [22-24].

Tabel 5. Hilsenhoff Biotic Index (HBI) values in all situ.

Months	HBI			
	SG	SP	SB	SL
January	2.00	2.18	2.79	2.17
February	2.00	2.14	2.00	2.20
March	2.00	2.05	2.04	2.29
June	2.00	2.00	2.04	2.15
July	2.00	2.02	2.28	2.13
Average	2.00	2.08	2.23	2.19

Based on cluster analysis, SG, SP and SB are belonged to the same group due to the similar water source of Situ Gede System. Meanwhile, SL is isolated with different water system. Situ Gede System could have an impact on the similarity of aquatic insects composition where the three situ are connected to each other. Abundance of aquatic insects was centrally gathered in SP, which is suitable aquatic habitat. SP has more aquatic vegetation than SG and SB. It was also surrounded by paddy and crops field, which is very different from the other situ. The abundance patterns of aquatic insects are very different with the Mollusca where aquatic insects can quickly move from SG and SB to SP [17]. There is no clear pattern of aquatic insect abundance and composition from the upstream to downstream portion of Situ Gede System.

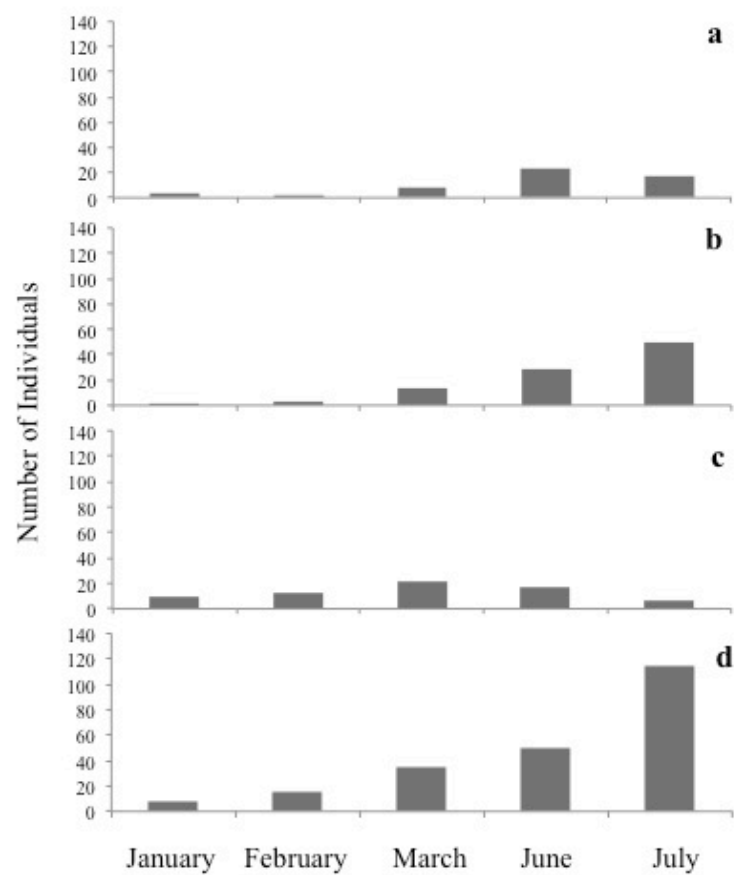


Figure 2. Abundance of Corixidae in SG (a), SP (b), SB (c), and SL (d) collected for five months

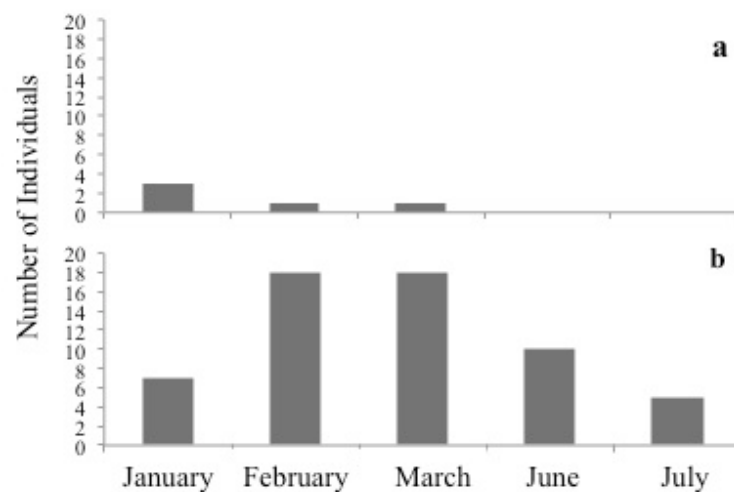


Figure 3. Abundance of Notonectidae in SG (a) and SP (b) collected for five months

Corixidae and Notonectidae prefer lentic aquatic system for their habitat [25]. Corixidae was the most dominant aquatic insects in four situ. Corixidae is widely distributed in many types of lake such as oligotrophic, mesotrophic and eutrophic lakes [26]. High nutrition of organic matters was found in all situ, which could enhance the food resources for Corixidae as a herbivore insect [27,18]. Corixidae had high abundance in June and July where the precipitation was low so the aquatic insects are not disturbed. Precipitation could affect flow of water, which can disturb away from their habitat [15]. Grandova [28] and Clifford [20] also reported that abundance of aquatic insect is enhanced in June. Some Corixidae reproduced from March to June and become higher in abundance in July [29]. Corixidae prefer pH 6 and range temperature 27-32°C [30] where the condition was similar in June and July. The other reason is low turbidity in June and July. Notonectidae was the second dominant family, which was only collected in SG and SP. Notonectidae is a predator, which prefer the shallow water [18, 29-30] where shallow water about 0.2-0.3 meter was showed in SP. Shallow water could help development process of Notonectidae from egg to imago. It needs to swim quickly and seek refuge around vegetation in shallow water to escape from predators [31]. In SP, Notonectidae was high in February and March where turbidity is low. Fadillah *et al* [12] reported that Notonectidae was also the second highest family in number of individuals after Libellulidae. Both Corixidae and Notonectidae have similar score of biotic index (2) and Biological Monitoring Working Party (BMWP) (5 for Corixidae and 4 for Notonectidae) [32]. It means they are able to modestly tolerate pollution.

HBI can be used to measure pollution level in aquatic system [8,29,33]. Range of HBI value in this study is 2.00-2.23, which describe the fairly polluted of organic matters (Table 2). The result was connected with water quality assessment based on DO where the water qualities from four situ were slightly polluted (table 6) [34]. However, the aquatic insects in four situ can still tolerate the pollution.

Table 6. Level of water quality based on Dissolved Oxygen (DO) [34]

No	DO Concentration (mg/L)	Water Quality
1	>6.5	Good
2	4.5 -6.4	Slightly polluted
3	2.0 – 4.4	Moderately polluted
4	<2.0	Severely polluted

5. Conclusion

Fourteen families of aquatic insects were recorded where Corixidae and Notonectidae were the most dominant family of aquatic insects in four situ. The highest abundance of aquatic insects was collected in SL, although the compositions of aquatic insects were not significantly different among four situ. Based on HBI, four situ were categorized into fairly polluted water quality.

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