EnvironmentAsia
The international journal by the Thai Society of Higher Education Institutes on Environment

EnvironmentAsia 13(3) 2020 80-88
DOI 10.14456/ea.2020.44
ISSN 1906-1714; ONLINE ISSN: 2586-8861

# Plankton Response to the Potential Acid Deposition in Situ Patengan Bandung

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Received: October 8, 2019; Revised: January 3,2020; Accepted: June 18, 2020

## Abstract

Acid deposition occurred as the impact of air pollution due to the increased emissions of $SO_2$ and NOx. If the acidic compounds fall into the inland aquatic (lake, river, or spring), it will disrupt the proliferation of organisms. Based on the previous study, low pH in inland aquatic generally affected the species diversity and plankton composition. This study aimed to figure out the impact of acid deposition in Situ Patengan - Bandung based on frequent monitoring. The study was undertaken in May, June, and September 2017 and March, June, October 2018 at 3 (three) sites, represented middle, inlet, and outlet of lake using survey method to conduct data collection. Plankton was identified using a microscope and calculated by the cell counting method. The results showed that the highest number of genera for phytoplankton in Situ Patengan was found in October 2017 whereas, the highest number of genera for zooplankton was found in May 2017. The range of diversity index (H') was 0.13 – 1.45 for zooplankton and 0.61 – 1.73 for phytoplankton. The dominance index of zooplankton was 0.25 - 0.68 and phytoplankton was 0.14 – 0.40. The pH of Situ Patengan range from 7.5 to 8.6, while the average concentration of dominant ions were 6.7 mg/L of $SO_4^{2-}$ and 6.2 mg/L of $Ca^{2+}$, respectively. Pearson correlation analysis of $H^+$ and the abundance of both zooplankton and phytoplankton showed a very weak correlation. The pH range of 7.5 – 8.6 did not significantly affect the abundance of plankton. There were no obvious impact of acid deposition on inland aquatic had been detected in Situ Patengan during the investigated period.

***Keywords:*** Acid deposition; Inland aquatic; Situ Patengan; pH; Plankton

## 1. Introduction

Acid deposition emerged when sulfur dioxide and nitrogen oxides are emitted into the atmosphere, then react with water, oxygen, and other chemicals to form more acidic pollutant and fall to the ground, mixed with rain, snow, or hail (Bealey *et al.,* 2014; EPA, 2014). Acidic pollutants are largely transmitted to the air due to fossil fuel burning and agricultural activities (Cerón *et al.,* 2013; EPA, 2014). US EPA stated that the ecological effects of acid rain are certainly detected in aquatic environments, where it can be toxic to fish and other wildlife.

Inland water acidification has been mostly influenced on aquatic organisms at sensitive regions in Europe and North America during the era of industrial revolution (EANET, 2010). Acidification has reduced the diversity and abundance of aquatic species in lakes and streams (Driscoll *et al.,* 2003; Duan *et al.,* 2016). Excess amount of acid in inland water reduced the number of surviving aquatic species. Types of plankton and invertebrates are the first organism which suffered from the effect of acidification (Eilers *et al.,* 1984).

Although acidification appeared due to natural water source, acidic drainage, or volcanic activity, anthropogenic activities also plays an important role (Driscoll *et al.,* 2003; EANET, 2010). Previously, the effect of acid deposition and increasing acidity of lakes on fish had been reported by Jensen and Snekvik (1972), Fromm (1980), Alabaster and Llyod (1980), Ikuta, Amano and Kitamura (1999) (Mustapha *et al.,* 2018). Ecological damages due to acidification of surface water were found in Scandinavia and North America (Duan *et al.,* 2016), and furthermore, several lakes in Canada were monitored to identify the impact of acid deposition (Jeffries *et al.,* 2003). Lowering pH levels, decreasing acid-neutralizing capacity, and increasing aluminum concentration in Adirondack and Catskill region of New York showed the impaired surface water due to acid deposition (Driscoll *et al.,* 2003; Zhou *et al.,* 2015).

The development of industrialization in East Asia increased the amount of pollutant emissions in the air, in which acid deposition occurred and potentially impact on ecological systems. Inland aquatic monitoring in Indonesia was conducted in Situ Patengan Bandung, West Java as a part of the participation of Indonesia in The Acid Deposition Monitoring Network in East Asia (EANET). The criteria of site monitoring was adopted from EANET Guideline (EANET, 2010). The recommended criterias for site selection were an oligotrophic lake with alkalinity less than 200 μeq/L, electroconductivity value less than 10 mS/m, low number of biological oxygen demands (BOD) and total organic compound (TOC), with no or minimal human activities (EANET, 2010). Situ Patengan was selected as a site of inland aquatic in Indonesia with the qualification to fit the harmony lake type with minimum anthropogenic activities, in addition, to consider the ease of access and efficiency of monitoring activities. Continuous monitoring of inland aquatic, water bodies, aquatic flora and fauna is needed to obtain the baseline data and to evaluate the current situation (EANET, 2010). Therefore, this survey type research was designed to detect the possible impact of acid deposition on plankton population dynamic in inland aquatic.

## 2.Material And Methods

### *2.1 Materials*

Materials used in this study were inland water sample, standard solution of $SO_4^{2-}$, $NO_3^-$, $Cl^-$, $Na^+$, $NH_4^+$, $K^+$, $Mg^{2+}$ and $Ca^{2+}$ ions, $NaHCO_3$, $Na_2CO_3$, $H_2SO_4$, and formalin.

### *2.2 Procedure*

#### *2.2.1 Sampling.*

Samples of inland aquatic were carried out in 3 (three) sampling sites in Situ Patengan Bandung for 6 (six) times in May, July, October 2017 and March, June, October 2018. The GPS location of Site 1 (S: 07°09’59.9’’ E: 107°21’23.0’’), Site 2 (S: 07º09’58.7’’ E: 107°21’35.8’’), and Site 3 (S:07°09’54.5’’ E:107°21’18.9’’) represented middle, inlet, and outlet of the lake. Sampling of plankton in the lake was conducted by taking out the plankton net mesh size 173 µm, both horizontally and vertically to collect 50 L of sample. Biological samples were treated by filtration and preserved. Plankton attached to net was sprayed until all plankton enter into 10 ml of glass bottle, and 3 drops of formalin 4% was added for fixation.

#### *2.2.2 Analysis of physical and chemical parameters*

##### *2.2.2.1 pH.*

pH was measured on site with pH meter HORIBA D55 using glass electrode, standardized with pH 4 and pH 7 reference buffers.

##### *2.2.2.2 Conductivity.*

Conductivity was measured on site by electro conductivitymeter HACH SenseIon5 using conductivity cell, calibrated with 0.0001 M, 0.0005 M, and 0.001 M KCl.

*2.2.2.3 Temperature.*

Water temperature was measured on site with thermometer or a portable water analysis with temperature sensor. Temperature was recorded at day time.

*2.2.2.4 Water depth, water clarity, and water color.*

Water depth was measured on site using LCD Digital Sounder Hondex PS-7, water clarity was measured on site using Secchi disk, and the color of water was observed by visual.

*2.2.2.5 Alkalinity.*

Water sample was taken to the laboratory, and alkalinity was measured by titration with 0.01 M $H_2SO_4$ using a pH meter to the end-point of 4.8.

*2.2.2.6 Ions.*

Ions of $SO_4^{2-}$, $NO_3^-$, $Cl^-$, $Na^+$, $NH_4^+$, $K^+$, $Mg^{2+}$ and $Ca^{2+}$ were determined using Ion Chromatography (IC) DIONEX ICS 5000, equipped by suppressor ASRS ULTRA II 2 mm and CSRS ULTRA II 2 mm, anion column IonPac AS12A, and cation column IonPac CS 12A with the flow rate of 1.5 L/minute. $NaHCO_3$ 0.3 mM and $Na_2CO_3$ 2.7 mM were used as anion eluent and Methane Sulphonic Acid (MSA) 20 mM as cation eluent. Samples were filtrated and injected into IC, and the concentration of ions were obtained through calibration curves

*2.2.3 Plankton identification.*

The identification of plankton types refers to Davis (1955). One ml of water sample was inserted into *Sedgewick-Rafter Counting Cells (SRCC)* cell, and examined under the microscope (magnification 100 and 200 times). The number of organism per millimeter was calculated in 10 $mm^2$ of 10 squares. Sedwick-Rafter used has a depth of 1 mm so that the volume of 1 box is 1 $mm^3$. Identification is carried out based on appropriate identification books up to genus.

*2.2.4 Data analysis.*

*2.2.4.1 Abundance.*

The abundance of plankton (individual/L) was calculated using formula:

$$N = \frac{C \times V1}{V2 \times V3} \quad (1)$$

where N = number of individual plankton per ml
C = number of counted plankton individual
$V_1$= volume of filtrated sample (5000 ml)
$V_2$= volume of testing sample (1 ml),
$V_3$= volume of sample (10 ml)

*2.2.4.2 Diversity index.*

Diversity index was calculated with Shannon Wienner index diversity by counting the species richness as follow:

$$H' = -\Sigma P_i \ln P_i \text{ with } P_i = n_i/N \quad (2)$$

where H'= diversity index
$n_i$ = individual number of species-i,
N = total individuals
$P_i$ = proportion of species-i.

Diversity index (H') is used to characterize genus group relation in the community, showing that diversity index with H'< 1= low species diversity, 1< H'< 3= medium species diversity, and H'> 3= high species diversity. The stability of community was equivalent with level of H'.

*2.2.4.3 Dominance index.*

Dominance index was calculated using formula:

$$C = \Sigma \left(\frac{ni}{N}\right)^2 \text{ ....................................(T3DB)}$$

where C = dominance index
Ni = number of individual at genus-i
N = total individual.

Dominance index (C) is used for knowing the extent to which a group of biota dominate other groups, with $0 < C \leq 0.5$ = small community, $0.5 < C \leq 0.75$ = medium community, while $0.75 < C \leq 1$ = large community

## 3. Results And Discussion

### *3.1 Physical and chemical parameters*

Based on the monitoring work, the physical lake water quality showed that average daily temperature was 22°C. The color of water was clear and greenish, water clarity were range from 0.2 to 2.0 m, and the depth varied from 2.3 to 9.0 m depend on the sampling season. The average conductivity and alkalinity were 5.3 mS/m and 0.5 meq/L, respectively. The average concentration of dominant ions were 6.7 mg/L of $SO_4^{2-}$ and 6.2 mg/L of $Ca^{2+}$. In this study, the pH values are ranged from 7.2 to 8.5. (Figure 1) These results are in agreement with those reported by Research Center of Water Resource (RCWR) Bandung wherein they conducted inland monitoring in Situ Patengan from 1999 to 2007, and the pH range were 7.7 to 8.4 (Brahmana *et al.,* 2009).

During 2008-2015, the weighted-precipitation mean of rainwater pH in Bandung was 5.3 (Lestari *et al.,* 2018), with the distance from LAPAN site in Bandung to Situ Patengan was around 52.8 km to the South East. The rainwater pH distribution in Bandung during 2017 to 2018 was shown in Figure 2. confirming that the number of acidic rainwater was less than the above of normal rainwater pH.

Despite the rainwater pH in Bandung area was potentially showed the indication of acid deposition, the impact of acidity itself on Situ Patengan has not yet apparent. The pH of Situ Patengan lake is still within the range of normal standard condition of inland aquatic in Indonesia as stated in government regulation (PP 82/2001) which is 6 to 9. Previous study in Situ Patengan shown that the pH value was ranged from 6 to 8 (Amanta *et al.,* 2012). Horne and Goldman (1994) also stated that the normal pH of lake was ranged from 6 to 9 (Horne *et al.,* 1994). Acidification process can be inhibited by a high soil buffer capacity and the level of alkalinity (Suzuki, 2003). The concentration of carbonate and bicarbonate ions were useful to maintain the stability of pH in water (Effendi, 2003).

The effect of acidification in lake is a threat to the ecosystem. It might breakdown the sustainability of food chain process that is serious matter to organisms. The pH data are often utilized as a basic parameter to determine the alteration of acidity in inland aquatic, though, measurements are only conducted occasionally and changes in pH can vary seasonally. The pH value in water represents a balance of acid and base in water, which is influenced by biological activities such as photosynthesis, respiration, temperature, and the presence of ionic compounds in water (Johnson, 1986).

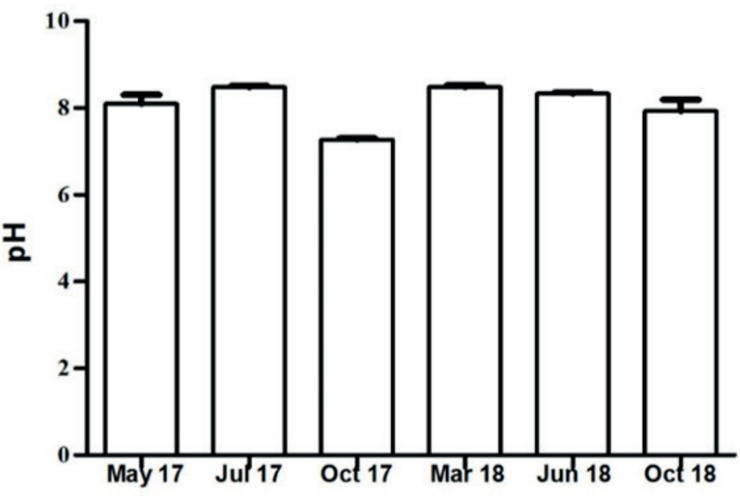


**Figure 1.** pH in Situ Patengan

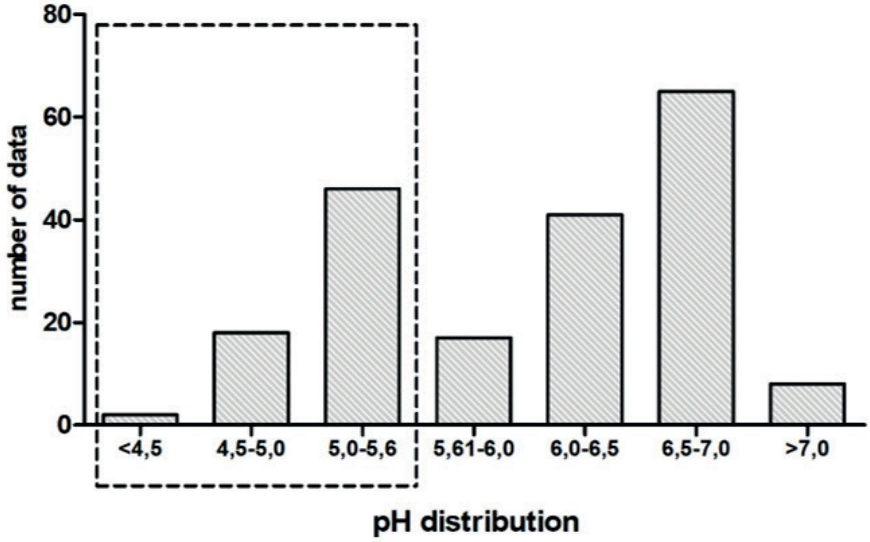


**Figure 2.** Rainwater pH distribution in Bandung 2017-2018

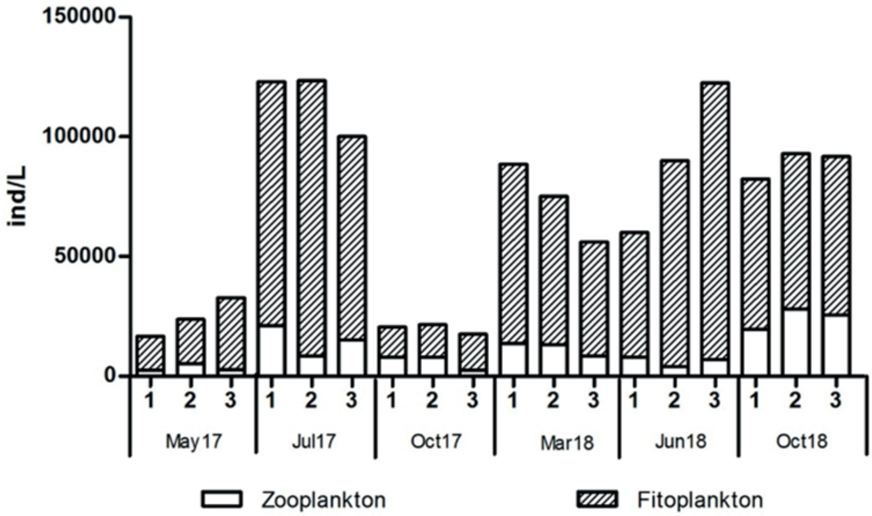


**Figure 3.** Plankton abundance in Situ Patengan. Number 1, 2, and 3 represented inlet, middle, and outlet of lake, respectively.

The sensitivity of aquatic organisms may vary, several types of plants and animals are able to endure acidic waters, however, the acid-sensitive species may be affected by declined pH (EPA, 2014). The most sensitive organisms tend to be affected if the pH<6.0, but more tolerant organism usually persist at pH 4.0 (Lovett *et al.,* 2007). Nevertheless, it was difficult to indicate strictly "a critical pH value" affecting floral and faunal changes, thus influencing overall aquatic ecosystem only by acidification progress (EANET, 2010). The individual species and their life stages, food-web structures, water chemical properties and many other complex combination affected the condition of organisms in response to acidification (EANET, 2010).

### 3.2 Plankton

To get more information about the possibility of acidification in Situ Patengan, biological analysis by identifying planktons were carried out. Phytoplankton is a primary producer for other higher organisms which is used as a benchmark for inland aquatic and as an indicator of the changes in biological quality of water (Handayani, 2008). Phytoplankton has the ability to absorb the solar energy directly to form organic matter, to carry out photosynthetic reactions (Handayani, 2008; Pitoyo *et al.,* 2002).

The abundance of phytoplankton as a basic nutritional diet in inland aquatic community was mostly higher than zooplankton. The average abundance of zooplankton was 11,138 individual/L (6.7%) and phytoplankton was 154,645 individual/L (93.3%) compared to total plankton.

The lowest and highest abundance occurred on October 2017 and October 2018, respectively. Compared to previous phytoplankton study, the result showed a higher result when the highest biomass of phytoplankton was *Bacillariophyceae* (7681.8 µg/L) while the lowest was *Pyrrophyceae* (306.7 µg/L) (Amanta *et al.,* 2012). Pearson correlation analysis of $H^+$ and the abundance of plankton showed a very weak or negligible correlation (r = 0.1).

An impact of acidification in inland aquatic is known to have an algae distribution of *Bacillariophyceae* and has narrow tolerance to pH (EANET, 2010). A lot of species which is largely distributed at pH lower than 7 and growing perfectly in acidic environment *(acidophilic),* also species which is optimally distributed at pH lower than 5.5 or only occurred in acidic environment *(acidobiontic).* By knowing these characteristics, the plankton set can be used as a part to explain the acidification process (EANET, 2010). To specify biological indicator species for acidification in phytoplankton, *Chrysophyceae* and *Bacillariophyceae* were recognized with their acid sensitivity characteristic (EANET, 2010). In zooplankton, of the *Cladocera* species, *Daphnids* and *Chydorids* exhibit low tolerance to acidity (EANET, 2010).

Based on identification, the composition of organisms in Situ Patengan were shown in Table 1.

**Table 1.** Plankton composition in Situ Patengan based on class and number of genera

| Group | Class | Number of Genera | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2017 | | | 2018 | | |
| | | May | August | Oct | March | June | Oct |
| Zooplankton | Branchiopoda | 3 | 1 | 2 | 1 | 2 | 1 |
| | Crutaceae | 2 | 1 | 2 | 1 | 1 | 1 |
| | Eurotatoria | 2 | 2 | 2 | 1 | 0 | 1 |
| | Sarcodina | 1 | 1 | 1 | 1 | 1 | 1 |
| | Monogononta | 0 | 0 | 0 | 0 | 2 | 3 |
| | Total | **8** | **5** | **7** | **4** | **6** | **7** |
| Phytoplankton | Chrysophyceae | 1 | 1 | 1 | 1 | 1 | 1 |
| | Dinophyceae | 1 | 1 | 1 | 1 | 1 | 1 |
| | Bacillariophyceae | 3 | 2 | 3 | 1 | 2 | 7 |
| | Chlorophyceae | 1 | 3 | 3 | 2 | 5 | 4 |
| | Zygnematophyceae | 5 | 5 | 4 | 3 | 3 | 1 |
| | Cyanophyceae | 1 | 4 | 5 | 2 | 5 | 2 |
| | Trebouxiophyceae | 1 | 1 | 1 | 0 | 0 | 2 |
| | Xanthophyceae | 0 | 1 | 1 | 0 | 0 | 0 |
| | Total | **13** | **18** | **19** | **10** | **17** | **18** |

Sulastri *et.al.* (2007) published the result of their research, showing that Situ Patengan was dominated by *Cyanophyceae* which might affected the fish life (Sulastri, 2003). In 2012, Amanta et al. found that the plankton in Situ Patengan consisted of 11 genera of zooplankton and 32 genera of phytoplankton (Amanta *et al.,* 2012). The highest mean abundance of phytoplankton was *Chlorophyceae* (97 individual/L) with *Spyrogira* as the most found genus, while in zooplankton was *Crustaceae* (32 individual/L) with *Cyclops* as the most found genus. The average diversity index of zooplankton was 0.65 while phytoplankton was 0.87 and both were classified as low type of diversity.

Compared to this study, plankton found in Situ Patengan during 2017-2018 is shown in Table 1. The highest number of genera for phytoplankton was found in October 2017 whereas, the highest number of genera for zooplankton was found in May 2017. The highest abundance in phytoplankton was found in October 2017 while the highest number of genera for zooplankton was found in May 2017. The highest abundance in phytoplankton was found in October 2017. the genus Zygnemopsis (80 individual/L) of the Zygnematophyceae class and the highest abundance in zooplankton is the genus Cyclops (33 individual/L) of the Crustaceae class.

Phytoplankton genus such as *Staurastrum* and *Micrasterias* could be an indicator for unpolluted waters (Abdel-Raouf *et al.,* 2012), however, those two genera were not found in Situ Patengan. In this study, acid deposition impact was not clearly seen. Nonetheless, there was an acidophilic species from genus *Nitzschia* found in a small amount (1 individual/L), and this does not count for acidification in Situ Patengan. *Nitzschia sp.* was included as a-mesosaprobic group to indicate a mild level of inland water pollution (Merilles *et al.,* 2018; Ramadhan *et al.,* 2016; Utomo *et al.,* 2013).

The diversity index (H') in Situ Patengan ranged from 0.13 to 1.45 for zooplankton and from 0.61 to 1.73 for phytoplankton. This indicated that the diversity of zooplankton and phytoplankton were considered as low to moderate. Those criteria of diversity might be caused by low nutrient of N and P content (Effendi *et al.,* 2016). Moreover, the average H' of phytoplankton was higher than zooplankton, showing a natural environment for all organisms to survive.

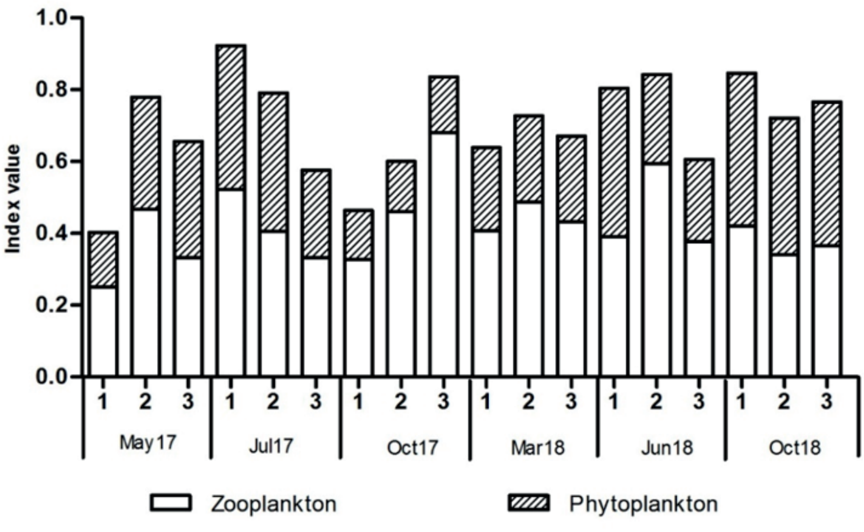


**Figure 4.** Diversity index of plankton in Situ Patengan. Number 1, 2, and 3 represented the site of inlet, middle, and outlet of lake, respectively.

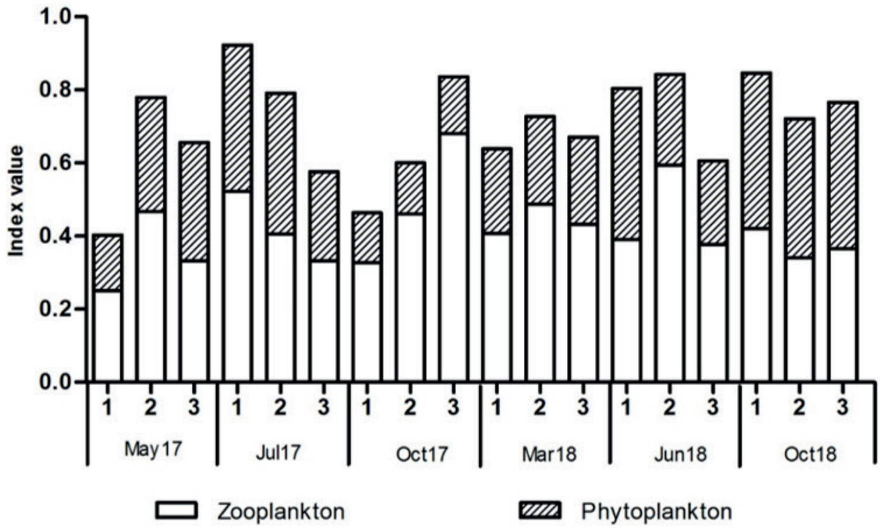


**Figure 5.** Dominance index of plankton in Situ Patengan. Number 1, 2, and 3 represented the site of inlet, middle, and outlet of lake, respectively.

After the plankton composition has been confirmed, dominance index was calculated to figure out what species could exist dominantly in Situ Patengan. The dominance index of zooplankton was range from 0.25 to 0.68 and classified as medium community, while phytoplankton was range from 0.14 to 0.40 and classified as a small community. The index value indicated that no specific species dominates at the site or the number of plankton were distributed or spread evenly (Odum, 1993).

## 4.Conclusion

There were no obvious impact of acid deposition on inland aquatic had been detected in Situ Patengan during the investigated period. However, ecological impact monitoring should be carried out to evaluate the present situation and predict the future trend.

## Acknowledgement

This study was funded by Ministry of Environment and Forestry Indonesia. The authors thanks the reviewers for their valuable comments.

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