The Relationship between Plankton Abundance and Abiotic Parameters in the Downstream Section of the Musi River, Palembang

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ABSTRACT

The Musi River, the largest river in Palembang in South Sumatera, has become one of its important sites, in which various activities such as shipping and irrigation are performed. Those activities are assumed to eventually affect the fertility of the waters. This research was conducted to accomplish three targets. The first was to analyze the abundance, diversity index (H'), uniformity (E), and the dominance of phytoplankton and zooplankton. The second target was to examine the difference in abundance of phytoplankton and zooplankton in the stations using ANOVA. The third was to analyze the relationship between the abundance of phytoplankton and zooplankton using PCA (Principal Component Analysis). Results revealed that the phytoplankton found downstream of the Musi River consisted of four classes, Bacillariophyceae, for instance, dominated the waters with a rate of 51.35%, followed by Chlorophyceae with a rate of 33.58% and the other two classes. The zooplankton consisted of twelve classes whose dominant class was Ciliate reaching 36.56% and followed by Mastigophora of 14.7%. It was also discovered that the diversity index (H') of plankton was moderate. Results indicate that the water condition was somewhere in between moderately and heavily polluted. The uniformity index (E) was high while the level of dominance (D) indicates that there was no dominant genus in the waters. Moreover, based on ANOVA, the abundance of plankton in the stations showed no significant differences. In addition, the abundance of zooplankton was influenced by four factors whose largest contribution was nitrite, TSS, and fosfat reaching 37.2%.

INTRODUCTION

The Musi River is one of the large rivers in South Sumatera located in three provinces: Bengkulu, Jambi, and South Sumatera. It consists of upstream, middle and downstream sections. The downstream, reaching 146 km, starts from Tebing Abang village, Muara
Enim Regency, to the mouth of Bangka Strait (Fisheries Ecological Survey Team, 1977; Wiadnyana & Husnah, 2011). This river has become the lifeblood of Palembang citizens as their means of transportation, housing and settlement, and fishing site as well (Eddy, 2013).

The mouth of Musi river acts as a fish resource with biomass reaching 24.5-105.47 kg/km² (Prianto & Suryati, 2010). The estuary is functioned as an ecosystem, spawning, and nursery ground for fish larvae. Thus, numbers of marine or fresh fish move to these waters (Prianto et al., 2013). However, in terms of the physical habitat of the river, based on both riverbed subtract and factors affecting the river health, the waters around Sebrang Ulu I and II tend to be in bad conditions (Trisnaini et al., 2018).

Remarkably, plankton are biotic organisms floating in waters. They consist of phytoplankton which are the plantlike community of plankton and zooplankton which are the animal-like community of plankton. Phytoplankton have chlorophyll and are several microns in size. Their lives depend on water movement which can indicate the quality of local waters (Harmoko & Krisnawati, 2017). Based on the saprobic status, the downstream of the Musi River is classified as lightly to moderately polluted while the other downstream sections, Kertapati and Gandus areas, show moderate to severe levels of pollution (Zulkiifi et al., 2009; Meiwinda et al., 2015). The phytoplankton found around Salah Nama Island are categorized as moderate (Dwirastina & Riani, 2019).

A research conducted on Musi River’s tributary, Komering River, reported that ten classes of phytoplankton were found with Bacillariophyceae as the most dominant class. Moreover, the research also showed that the diversity index was moderate, dominant phytoplankton species was found, and the physico-chemical parameters were regarded as stable (Tawanggian et al., 2020). The Skeletonema genera had experienced an explosive population growth reaching 98.71% of the total population at the mouth of Banyuasin estuary. This condition indicated an increase in nutrients on the coast (Aryawati et al., 2018).

Hence, the current research aimed: (1) to analyze the abundance, diversity index (H’), uniformity (E), and dominance of phytoplankton and zooplankton; (2) to examine the difference in abundance of phytoplankton and zooplankton in the stations using ANOVA, and (3) to analyze the relationship between phytoplankton and zooplankton abundance using PCA (Principal Component Analysis).

MATERIAL AND METHODS

The research field was carried out in the waters of the downstream section of the Musi River, Palembang, and South Sumatera Province, Indonesia in July 2019 at high tide. Random sampling was performed at six observation points: (1) the first point, located in Ampera bridge (02° 59’ 25" S, 104° 45' 55" E); (2) the second point, in Boom Baru port (02° 58’ 55" S, 104° 46’ 44" E); (3) the third point, located in Sriwijaya fertilizer factory

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**Relationship between Plankton Abundance and Abiotic Parameters in Musi River**

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(02° 59' 05" S, 104° 47' 46" E); (4) the fourth point, in Pertamina's refinery jetty (02° 59' 21" S, 104° 50' 03" E); (5) the fifth point, in a shipyard owned by Mariana Bahagia Company (02° 58' 02" S, 104° 52' 12" E), and the sixth point, in the shrimp processing area and SAP’s palm oil mill (02° 57' 30" S, 104° 52' 44" E) (Fig. 1).

![Fig. 1. Research sites.](image)

Thirteen parameters were studied ranging from physical to chemical parameters that affected the abundance of phytoplankton and zooplankton. The physical parameters included temperature, turbidity, and current velocity. The chemical parameters included TDS (Total Dissolved Solid), TSS (Total Suspended Solid), salinity, nitrate, nitrite, pH, phosphate, BOD (Biological Oxygen Demand), and DO (Dissolved Oxygen). Besides, another parameter that affected the photosynthesis of aquatic organisms was depth. While, water temperature, TDS, and the pH values were identified using HM Digital COM-300. Water salinity was studied using Saltmeter CT-3080, whereas the water turbidity was measured by the WGZ-1B Portable Turbidity Meter. On the other hand, the parameters of TSS, nitrate, nitrite, phosphate, BOD, and DO were studied at Industrial Research and Standardization Centre of Palembang. The current velocity measurement was performed using FL 03 Flow watch. The position of each station was identified and determined using Garmin eTrex 30x type GPS device, whereas water depth was measured using a measuring line.

The abundance of phytoplankton and zooplankton was analyzed using APHA formula, while the level of diversity was examined using Shannon-Wiener diversity index (H') (APHA, 1989; Odum, 1996). The diversity index value can be classified into three categories: (a) H' < 1 - low diversity and low community stability, (b) 1 ≤ H' ≤ 3 - medium diversity and moderate community stability, and (c) H' > 3 - high diversity and high community stability (Odum, 1996). The uniformity index (E) was calculated using Poole formula, where E ranges from 0-1. E > 0.6 indicates a high uniformity of species. 0.6 ≥ E
≥ 0.4 indicates a medium uniformity. E <0.4 means that the uniformity of species is low (Odum, 1996; Supono, 2008). Simpson’s index of dominance (D) was applied to determine the dominance of certain species in waters. Dominance index between 0-1; D = 0, means that there are no dominant species or the community structure is stable while D = 1, indicates that dominant species exist or the community structure is unstable due to ecological pressure (Odum, 1996; Kartika et al., 2015).

In this research, the data were tested using One Way Anova in order to determine the existence of the statistically significant differences between the means of two or more independent groups. The tests which can be performed on the output are Homogeneity of Variances, ANOVA, and Post Hoc (Tukey HSD and Bonferroni Test) (Santoso, 2015). The research data included the abundance of phytoplankton and zooplankton at the six stations. The hypothesis stated that, H₀ = abundance of phytoplankton/zooplankton at six stations was the same and H₁ = abundance of phytoplankton/zooplankton at six stations was different.

The data including the abundance of phytoplankton, zooplankton, temperature, TDS, salinity, TSS, nitrite, nitrate, phosphate, BOD, DO, and turbidity were analyzed using PCA processed with IBM SPSS Statistics 25. The PCA analysis is accessed by grouping the data statistics to identify the relationship between phytoplankton and zooplankton abundance using chemical physics parameters (Arazi et al., 2019). Factor analysis can also be used to determine the correlation matrix of respondents based on their characteristics (Ghozali, 2013). The PCA is used to summarize the correlation pattern between variables, reduce a number of variables into small factors, provide operational definitions of the main dimensions of the use of observed variables, and test the underlying theory (Umar, 2009; Tabachnick and Fidell, 2019).

**RESULTS AND DISCUSSION**

Phytoplankton are identified as microscopic organisms which float in waters. They consist of five major groups: *Cyanophyta* (blue algae), *Chlorophyta* (green algae), *Chrysophyta* (yellow algae), *Pyrophyta*, and *Euglenophyta* (Nybakken, 1992; Asriyana & Yuliana, 2012). In the downstream section of the Musi River, four classes of phytoplankton were found: *Bacillariophyceae*, *Chlorophyceae*, *Cyanophyceae*, and *Dinophyceae*. Some genera of each class were also found: 17 genera of *Bacillariophyceae*, 11 genera of *Chlorophyceae*, 3 genera of *Cyanophyceae* and only one genera of *Dinophyceae* (Table 1).

The abundance of phytoplankton ranged between 456.11 and 958.4 individual/l. The highest abundance was found at the refinery jetty at the estuary of Komering River, while the lowest was found at Boom Baru port. The abundance was dominated by *Bacillariophyceae* class with a dominance rate of 51.35%, followed by the *Chlorophyceae* class by 33.58%, and the rest were *Cyclotella* and *Dinophyceae*. This
finding corresponds to that of Bahri (2005) who reported that, the most dominant plankton were Bacillariophyceae and Chlorophyceae, and added that zooplankton of Rotifera class were higher in numbers than those of Copepoda and Cladocera classes. The dominance rate of Bacillariophyceae reached 98.33% followed by Chlorophyceae which were also found in the waters of Bangka Strait (Isnaini et al., 2014). The abundance of Bacillariophyceae class was attributed to the ability to adapt to the environmental conditions (Munthe et al., 2012).

Table 1. The abundance of phytoplankton in the downstream section of the Musi River

<table>
<thead>
<tr>
<th>No.</th>
<th>Class/Genera</th>
<th>Station 1</th>
<th>Station 2</th>
<th>Station 3</th>
<th>Station 4</th>
<th>Station 5</th>
<th>Station 6</th>
</tr>
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<tr>
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<td>108.17</td>
<td>58.34</td>
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<td>0</td>
</tr>
<tr>
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<td>22.33</td>
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<td>6</td>
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<td>58.34</td>
<td>41.67</td>
<td>41.84</td>
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<td>83.34</td>
<td>41.67</td>
<td>16.5</td>
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<td>72.33</td>
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<td>91.67</td>
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<tr>
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<td>8.34</td>
<td>0</td>
<td>41.67</td>
</tr>
<tr>
<td>13</td>
<td>Rhizosolenia</td>
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<td>11</td>
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<td>0</td>
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</tr>
<tr>
<td>14</td>
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<td>0</td>
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<td>16.67</td>
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<td>50</td>
<td>58.17</td>
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<tr>
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</tr>
<tr>
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</tr>
<tr>
<td></td>
<td>Chlorophyceae</td>
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</tr>
<tr>
<td>18</td>
<td>Actinastrum</td>
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<td>Ankistrodesmus</td>
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<td>Coscinodiscus</td>
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<td>8.34</td>
<td>8.5</td>
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</table>
The present findings showed the existence of eleven classes of zooplankton. The classes included Ciliates, Rotifers, Crustaceans, Eurotatoria, Tubulinea, Brachiopoda; while Mastigophora classes, included Oligophrenophorea, Monogononta, Tentaculata, and Hexananauplia. Moreover, in each class, there was only one genera found. The abundance of zooplankton ranged from 6.5 to 11.64 ind/l and the highest abundance was found at Boom Baru port. The Ciliates class was the most dominant reaching 36.56%, followed by Mastigophora class 14.7%, and Rotifers 10.94% (Table 2).

The abundance of plankton in the downstream waters of the Musi River was relatively low and fluctuated. The abundance often included Cladocera, Copepoda, and Rotifera groups (Adjie, 2007; Prianto et al., 2008; Samuel et al., 2013).

Table 2. The abundance of zooplankton in the downstream section of Musi River

<table>
<thead>
<tr>
<th>No.</th>
<th>Genera/Class</th>
<th>Station</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<td>3</td>
<td>4</td>
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<td>6</td>
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<td>27</td>
<td>Spirogyra</td>
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<td>105.67</td>
<td>125.17</td>
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<tr>
<td>28</td>
<td>Monoraphidium</td>
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<td>0</td>
<td>8.34</td>
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<td>0</td>
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<tr>
<td></td>
<td>Cyanophyceae</td>
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<tr>
<td>29</td>
<td>Chroococcus</td>
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</tr>
<tr>
<td>30</td>
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<td>0</td>
</tr>
<tr>
<td>31</td>
<td>Oscillatoria</td>
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<td>44.33</td>
<td>0</td>
<td>75.17</td>
<td>200</td>
<td>116.67</td>
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<tr>
<td></td>
<td>Dinophyceae</td>
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</tr>
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<td>32</td>
<td>Prorocentrum</td>
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<td>11.22</td>
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<td>16.67</td>
<td>16.84</td>
</tr>
<tr>
<td></td>
<td>Genera</td>
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<td>16</td>
<td>13</td>
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<td></td>
<td>Total</td>
<td></td>
<td>573.35</td>
<td>456.11</td>
<td>517.55</td>
<td>958.4</td>
<td>833.89</td>
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</table>
The diversity index ($H'$) of phytoplankton ranged between 2.02 and 2.21, and the highest was at the fourth point; the refinery jetty. This finding showed that the diversity of phytoplankton was moderate. The uniformity index ($E$) ranged between 0.81 and 0.9; and the highest was at Boom Baru port, while the lowest was in the shipyard area. Moreover, uniformity indices of all stations were high. The dominance level ($D$) of phytoplankton ranged between 0.15 and 0.19, and the highest was found in the shipyard area, while the lowest was found at the other stations. It was also found that all stations show no dominant genera (Fig. 2).

![Fig. 2. Phytoplankton’s diversity, uniformity and dominance](image-url)

<table>
<thead>
<tr>
<th>Genera</th>
<th>Tubulinea</th>
<th>Branchiopoda</th>
<th>Mastigophora</th>
<th>Oligohymenophorea</th>
<th>Monogononta</th>
<th>Hexanauplia</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
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<td>1</td>
<td>0.5</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Paramecium</strong></td>
<td>1.33</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Conochiloides</strong></td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Notholca</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Diaptomus</strong></td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7.66</td>
<td>11.64</td>
<td>8</td>
<td>7.5</td>
<td>6.5</td>
<td>12</td>
</tr>
</tbody>
</table>
The average diversity index (H') of zooplankton was 1.58, ranging from 1.46 and 1.85; the highest diversity was found in the palm oil mill, while the lowest was found around the Ampera bridge. The diversity index of zooplankton was moderate. It means that the waters were moderately to heavily pollute. The findings showed that the uniformity index (E) was 0.89 and 0.95; the highest uniformity was obtained in the shipyard while the lowest was found in Boom Baru port. It showed that all stations had high uniformity of zooplankton. The dominance index (D) ranged from 0.19 to 0.26. The highest was found at the refinery jetty while the lowest was found in the fertilizer factory. The dominance index of all stations showed no dominant genera (Fig. 3).

Additionally, it was found that water temperature ranged from 34.33 to 38.67°C; the highest temperature was in the palm oil mill. Water temperature for phytoplankton and zooplankton ranged, respectively, from 25-30°C and 15-35°C (Kadir et al., 2015). The findings showed a temperature distribution which exceeded deviation 3 and was heterogeneous; the condition was not optimum temperature for phytoplankton growth but on the other hand, it was good for zooplankton growth.

According to water quality standard, the downstream water of the Musi River, starting from Jaran Strait to the estuary, was categorized as class III as the water was used for freshwater culture, livestock, and irrigation (Regulation of the Governor of South Sumatera Province No.16 of 2005). The TDS ranged from 38.9 to 41.57 mg/l and the highest was found at station 6. On the other hand, the TSS ranged from 0.23 to 0.63 mg/l and the highest was found at station 1. The TDS and TSS values still met the quality standard (1000 and 400 mg/l). It was also found that the salinity was 0.04 ppt which indicates that the downstream was not affected by the sea. Moreover, the nitrite was 0.05-0.26 mg/l and the highest was at station 3. On the other hand, the nitrate ranged from 4.88 to 12.5 mg/l and the highest was found at station 3. The nitrate content exceeded the water
quality standard (0.008 mg/l) \textit{(Decree of Minister of Environment No.15 of 2004)} (Table 3).

Based on the findings, the pH value reached 5.12-5.25 which was not an optimum pH for biota. This acidic water was influenced by the open land in the upstream including palm oil plantations, the activities of palm oil industry, and the surrounding community \textit{(Soraya et al., 2014)}. It was also found that the phosphate ranged from 0.1 to 0.28 mg/l and the highest finding was at station 2. This value exceeded the quality standard. This finding is in accordance with a previous research conducted on Banyuasin river estuary which showed that the phosphate and nitrate content exceeded the quality standard due to the influence of the river upstream \textit{(Aryawati et al., 2017)}.

The BOD ranged from 8.33 to 14.67 mg/l, the highest and lowest was found at stations 4 and 2. The BOD values were below the quality standard for biota which was 20 mg/l, and the condition was not suitable for biota.

It was found that the DO reached 7.01-7.25 mg/l and the highest was found at stations 5 and 6. If the DO content was > 5 mg/l, it was good for plankton due to the high phytoplankton abundance \textit{(Ulqodry et al., 2010; Dewanti et al., 2018)}. The high content of the DO is possibly caused by the household waste. The turbidity ranged between 24.43 and 59.7 and the highest NTU (Nephelometric Turbidity Units) was found at station 4, indicating that it exceeded the quality standard (value <5 mg/l). Moreover, some parameters exceeded quality standards for biota: temperature, nitrate, pH, BOD, and turbidity. On the other hand, the content of the TDS, the TSS, and the nitrite still met the quality standard.

\begin{table}[h]
\centering
\caption{Physical and chemical quality of downstream section of Musi River (Mean & SD)}
\begin{tabular}{lcccccc}
\hline
Parameter & 1 & 2 & 3 & 4 & 5 & 6 \\
\hline
Temperature (°C) & 32±2.72 & 34±1 & 35.27±1.1 & 34.33±1.4 & 38.53±1.05 & 38.67±1.53 \\
TDS (mg/l) & 38.5±1.22 & 37.43±0.23 & 37.7±0.26 & 38.9±0.1 & 41.57±2.48 & 41.57±0.35 \\
Salinity (ppt) & 0.04±0 & 0.04±0 & 0.04±0 & 0.04±0 & 0.04±0 & 0.04±0 \\
TSS (mg/l) & 0.63±0.49 & 0.27±0.12 & 0.5±0.2 & 0.33±0.25 & 0.3±0.1 & 0.23±0.06 \\
Nitrite (mg/l) & 0.16±0.03 & 0.19±0.05 & 0.26±0.18 & 0.11±0.08 & 0.05±0.02 & 0.1±0.07 \\
Nitrate (mg/l) & 11.01±1.99 & 4.88±6.42 & 12.5±9.47 & 10.38±7.97 & 10.44±1.47 & 10.8±1.92 \\
pH & 5.12±0.18 & 5.16±0.19 & 5.15±0.21 & 5.22±0.19 & 5.21±0.22 & 5.25±0.18 \\
Phosphate (mg/l) & 0.22±0.19 & 0.28±0.22 & 0.15±0.05 & 0.12±0.03 & 0.11±0.06 & 0.1±0.03 \\
BOD (mg/l) & 11.67±3.21 & 14.67±5.69 & 11±3.46 & 8.33±7.51 & 10±5.2 & 11±2.65 \\
DO (mg/l) & 7.04±0.6 & 7.09±0.1 & 7.01±0.1 & 7.13±0.16 & 7.25±0.17 & 7.25±0.19 \\
Turbidity (NTU) & 34.13±5.25 & 24.43±0.51 & 25.77±1.25 & 59.07±50.87 & 24.77±0.7 & 33.6±7.3 \\
Current speed (m/s) & 0.2 & 0.16 & 0.17 & 0.11 & 0.41 & 0.28 \\
Depth (m) & 0.14 & 10.8 & 0.2 & 1.1 & 7.7 & 6.9 \\
\hline
\end{tabular}
\end{table}
Based on the difference test on phytoplankton abundance found in the stations using One Way Anova, it was found that the average abundance of stations 1 - 6 was 20.95 ind/l which included 192 data. The minimum abundance was found at station 2 and the maximum was at station 4. The hypothesis of this research said that \( H_0 = \) the abundance of phytoplankton at six stations was the same while \( H_1 = \) the abundance of phytoplankton at six stations was different. According to Levene test, the statistics showed that the values were 2,624; 0.771; 0.771; and 1.608 with the probability values that reached 0.26; 0.571; 0.572; and 0.16. If each probability was > 0.05 then \( H_0 \) was true; meaning that the abundance of phytoplankton at the six stations was the same. By comparing \( F_{\text{statistic}} \) with \( F_{\text{table}} \), assuming that \( F_{\text{output}} < F_{\text{table}} \), it was found that 0.707 < 2.21 then \( H_0 \) was accepted; meaning that the abundance of phytoplankton at the six stations was the same.

On the other hand, based on the comparison test on zooplankton abundance found in stations using One Way Anova, it was found that the average abundance of stations 1 - 6 was 0.47 ind/liter which included 114 data. The minimum abundance was found at station 5 and the maximum was at station 2. The hypothesis of this research said that \( H_0 = \) the abundance of zooplankton at six stations was the same while \( H_1 = \) the abundance of zooplankton at six stations was different. According to Levene test, the statistics showed that the values were 0.763; 0.305; 0.305; and 0.363 with the probability values that reached 0.579; 0.909; 0.909; and 0.873. If each probability was > 0.05 then \( H_0 \) was true; meaning that the abundance of zooplankton at the six stations was the same. By comparing \( F_{\text{statistic}} \) with \( F_{\text{table}} \), assuming that \( F_{\text{output}} < F_{\text{table}} \), it was found that 0.456 < 2.21 then \( H_0 \) was accepted; meaning that the abundance of zooplankton at the six stations was the same.

There were 12 variables tested using PCA: the abundance of phytoplankton, the abundance of zooplankton, temperature, TDS, TSS, nitrate, nitrite, pH, phosphate, BOD, DO, and turbidity. Nine variables met the requirements with eigenvalues > 1 including temperature, TDS, TSS, nitrate, nitrite, phosphate, DO, turbidity, and the abundance of zooplankton. KMO (Kaiser-Meyer-Olkin) test resulted in value of 0.587 which means that the factor analysis could be done and has met the requirements. The findings also showed that the four factors which influenced the results were found with a total contribution of 82.23% resulted from 37.2%, 15.95%, 15.7%, and 13.39%. The four factors had positive correlation and the value was > 0.5 including factor 1 up to factor 4. Factor 1 included nitrite, TSS, phosphate, and zooplankton abundance; factor 2 was TSS; factor 3 was TDS; and factor 4 was zooplankton abundance.

Factor 1 was labelled as chemical and biotic parameter; factor 2 was physical parameter 1. Factor 3 was labelled as physical parameter 2 while factor 4 was the primary producer biotic factor. The zooplankton abundance was influenced by four factors and the largest contribution was factor 1 reaching 37.2%, including the nitrite, TSS, and
phosphate. TSS and TDS (factors 2 and 3) evenly influenced the results reaching 15.59% and 15.7% while the rest (zooplankton abundance) was only 13.39% (Fig. 4).

![Fig. 4. The graph of PCA](image)

On the other hand, some factors were negatively correlated: factor 1 (DO), factor 2 (DO), factor 3 (nitrate), and factor 4 (turbidity). It means that the higher the DO and nitrate content were, the lower the abundance of zooplankton. This condition could cause a greater phytoplankton population. A very significant contribution of factor 1 came from nitrite (0.81); TSS’s contribution was fairly significant (0.7); the phosphate’s (0.53) and zooplankton’s abundances (0.52) were moderate. A research conducted at Sugihan estuary showed a distribution in river water consisting of light intensity, temperature, nitrate, phosphate, *Pleurosigma* and *Pseudo-nitzschia* (Mulyadi et al., 2019).

Water fertility which included the abundance of Belida fish was influenced by the presence of plankton, including genera *Ulothrix, Mytilina* and abiotic factors, including TDS, electrical conductivity, waters temperature, chlorophyll-a, flow rate, BOD, DO, pH, alkalinity, and the absence of CO₂ (Wibowo et al., 2009). This water fertility was beneficial for phytoplankton in order to perform photosynthesis (Purnamaningtyas et al., 2017). Research conducted in Sungsang, the estuary of Banyuasin River, which applied PCA found that phytoplankton biodiversity was characterized by diversity index, uniformity, dominance, phosphate, abundance, temperature, pH and salinity (Pratama et al., 2019). The high abundance of *Baccillariaphyceae* positively correlated with the DO chemical parameters. However, it negatively correlated with phosphate (Ismunarti, 2013). The fish abundance in this estuary was influenced by salinity, ammonia, and the abundance of phytoplankton (Rais et al., 2017).

**CONCLUSION**

The phytoplankton found in the downstream section of the Musi River consisted of four classes including *Baccillariaphyceae, Chlorophyceae, Cyanophyceae,* and *Dinophyceae*. The abundance of *Bacillariophyceae* dominated the waters reaching
51.35% followed by *Chlorophyceae* 33.58%. The findings also showed that the zooplankton found in the waters consisted of twelve classes with *Ciliata* as the dominant class reaching 36.56%, followed by *Mastigophora* 14.7%. The plankton diversity index (H') was moderate which means that the waters were moderately to heavily polluted.

The uniformity index (E) was high while the level of dominance (D) indicated that there was no dominant genus found in the waters. The comparison test of ANOVA showed that the abundance of plankton of the stations was not significantly different or in other words, they were the same. Out of the twelve variables tested using PCA, 9 variables were found influencing the abundance of zooplankton: temperature, TDS, TSS, nitrate, nitrite, phosphate, DO, and turbidity. There were four factors which influenced the findings with a total contribution of 82.23% taken from 37.2%, 15.95%, 15.7% and 13.39%. Zooplankton abundance was influenced by four factors with the largest contribution of factor 1 reaching 37.2% including nitrite, TSS, and phosphate.

**REFERENCES**


Pratama, F.; Rozirwan; and Aryawati, R.(2019). Dynamics of phytoplankton communities during the day and night in the waters of the village of Sungang, the mouth of Musi River, South Sumatera. Jurnal Penelitian Sains, 21(2): 83-97.


**Regulations**

- **Decree of Minister of Environment No.15 of 2004** on Quality standards of seawater.
- **Minister of Environment Decree No. 51 of 2004** on Sea water quality standard.
- **Regulation of the Governor of South Sumatera Province No.16 of 2005** on Designation of water and river water quality standards.