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Saprobic plankton index as bioindicator determines pollution status in Green Canyon River, Pangandaran, Indonesia

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ABSTRACT

Rivers generally have pollution potential, which from industrial waste, domestic waste or high human activities, especially in rivers designated as tourist destinations, such as along the Green Canyon River which is used as a research location. The purpose of this research was to determine the level of pollution along the Green Canyon River, Pangandaran. This research focuses on the saprobic index method using plankton as a group composer of saprobic waters which is become a pollution indicator. This research was conducted from September up to November 2018. Sampling was taken at five different stations. The results of this research indicate that the saprobic value of the index along the Green Canyon River, Pangandaran River ranges from 1.0 to 1.5 which indicates that waters are being in very low pollution up to low pollution. The lowest saprobic index value was found at station 4 with the use of the mangrove area and the highest saprobic index value was found at station 2 which was the first brackish point that dominated with forest and far from residential settlements. Identified plankton consists of 8 genera of phytoplankton and 2 genera of zooplankton with abundance until 2495 individual/L. The average of diversity index in range 0.99-1.02 with an average of dominance in range 0.103-0.121.

Keywords: Saprobic index, Plankton, Green Canyon River

1. INTRODUCTION

Rivers in Indonesia generally experience damage due to deforestation, destruction of edge vegetation, removal of streams, removal and regulation of flows, disposal of waste from settlements, agriculture, industry, sand mining, over-exploitation of endemic species and introduction of foreign species (Dudgeon 1992). The Green Canyon River passes in the Kertayasa area, Cijulang District, Pangandaran Regency, West Java and is about 31 km from Pangandaran Beach which functions as a tourist destination. The potential for pollution in the Green Canyon River can come from residential areas, tourism activities and there are food factories making nata de coco in the downstream area. One of the problems of Green Canyon is the threat of river ecosystems due to the utilization of rivers that are not yet optimal and sustainable (Trigantiarsyah and Mulyadi 2016; Pratiwi et al. 2018).

Plankton is used as an indicator of water quality because of its short life cycle and rapid response to environmental changes. Besides, the presence of phytoplankton can indicate the fertility of an aquatic environment (Nurruhwati et al. 2017). Plankton has tolerant properties and different responses to each change in water quality as the basis for using plankton as an indicator of the saprobic index. The saprobic index of plankton is a way to detect the pollution of organic matter that is associated with the composition of plankton in it. Restoration of ecosystem functions can be done by restoring the physical and biological functions of the ecosystem and increasing human awareness of the importance of protecting the ecosystem.

2. MATERIALS AND METHODS

2. 1. Time and Place

The research location is in the Green Canyon River, Cijulang District, Pangandaran Regency, West Java. Sampling was carried out at 5 stations with 3 replications during September - November 2018. The determination of stations in this research was conducted based on differences in land use.

2. 2. Materials

The tools used in this research are the Secchi disk, Thermometer, Current meter, Refractometer, pH meter, DO meter, Spectrophotometer, Winkler bottle, Plankton net, Pipette drops, Sample bottle, Label, Freshwater algae, Camera, Cool box. The material used is plankton and Lugol.

2. 3. Method

The research method uses survey methods and sampling is done by purposive sampling, which is a method of retrieving data that is tailored to research needs.

2. 4. Data Analysis Method

Data analysis included a saprobic index, abundance, diversity, and dominance.

2. 4. 1. Saprobic Index

$$SI = \frac{1C + 3D + 1B - 3A}{1A + 1B + 1C + 1D}$$

SI = Saprobic Index; A = Number of Species of Polysaprobic Organisms; B = Number of Species of α -Mesosaprobic Organisms; C = Number of β -Mesosaprobic Organism Species; D = Number of Species of Oligosaprobic Organisms

2. 4. 2. Plankton Abundance

$$N = n \times \left(\frac{V_r}{V_o}\right) \times \left(\frac{1}{V_s}\right)$$

N = Plankton Abundance (ind/L); n = Number of identified plankton; Vr = Volume of Filtered Plankton (ml); Vo = Volume of Calculated Plankton (ml); Vs = Volume of Filtered Plankton (L)

2. 4. 3. Plankton Diversity

$$D = 1 - \sum(P_i)^2$$

D= Simpson Diversity Index; Pi= ni/N; ni= Number of genus individuals to-i; N= Number of individual total; n= Genus Number i = 1,2,3,..., n

2. 4. 4. Dominance

$$C = \sum \left[\frac{n_i}{N}\right]^2$$

C = Dominance Index; ni = Number of individual species to-i, N = Total number of individuals

3. RESULTS AND DISCUSSION

3. 1. Physical and Chemical Parameters in the Green Canyon River Stream

This research measures the physical and chemical parameters found in the Green Canyon River flow (Table 1). The presence of plankton is strongly influenced by physical and chemical factors in the waters (Chaudhary and Pillai 2009). Transparency ranges from 64-190 cm. Transparency of water is inversely proportional to turbidity which is influenced by the suspension of organic and inorganic materials dissolved in the waters. Almost all transparency stations reach the bottom of the water.

The average range of temperatures at five stations is 27-31 °C (Table 1). This condition can support the life of plankton. The optimal temperature range for phytoplankton growth, in general, is 20 – 30 °C. The degree of acidity (pH) in the Green Canyon River flow ranges from 5.94 - 8.4 (Table 1). The pH reaching 5.94 is found at station 5 (river mouth) caused by the

station being affected by the nata de coco factory. States that the pH of polluted waters due to the food industry can have a pH of up to approximately equal to 5 or more than 8. The pH value at station 1 reaches 8.4 due to being surrounded by alkaline limestone cliffs. Decreasing pH at the third sampling (November) due to the rainy season which has the potential to reduce the pH of the waters. Rain can affect the pH value of the waters to be lower (Sahidin et al 2019).

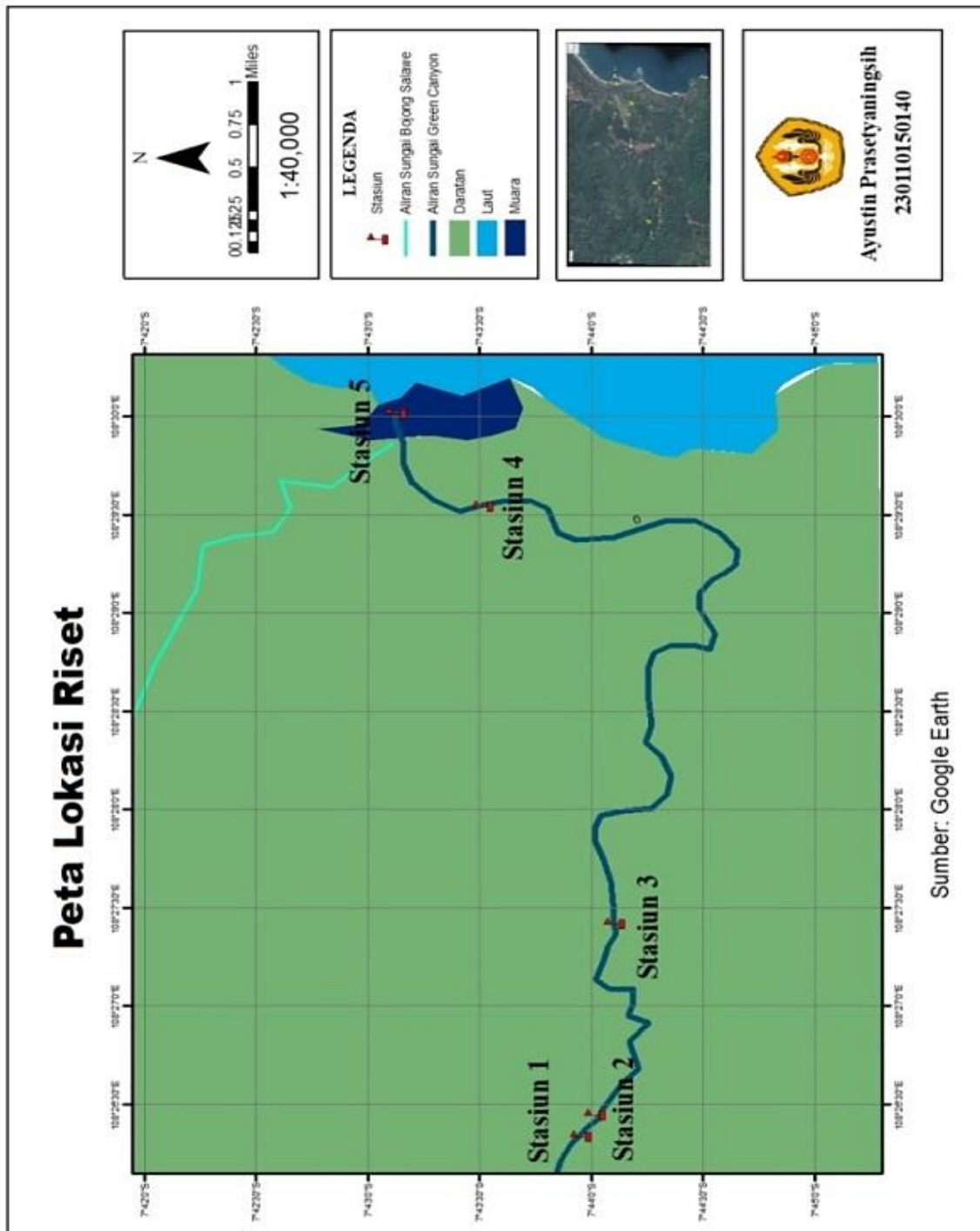


Figure 1. Research Location Map

Salinity in the Green Canyon River flow ranges from 6.67 - 28.3 ppt (Table 1). The lowest salinity is found at station 1 which is the zone of freshwater and the highest is at station 5 which is the estuary area and adjacent to the sea.

The average of dissolved oxygen concentration in the waters found in the Green Canyon River, Pangandaran has a range between 7.4 - 9.67 mg / L (Table 1). Waters with DO concentrations of more than 5 mg / L indicate low levels of pollution. More than 4 mg/L DO is required in waters to support aquatic biota life. The standard for dissolved oxygen according to Government Regulation Number 82 of 2001 is ≥ 4 (for station 1) and the Ministerial decree of Living Environment Number 51 of 2004 for marine biota and tourism > 5 mg / L (for stations 2, 3, 4, 5). Based on these criteria it is known that dissolved oxygen concentration still matches the quality standard. The range of current data in all stations is 0.04 m³/sec - 0.21 m³/sec (Table 1). The highest current velocity is at station 1 which has the condition of a region with heavy currents. Station 4 has the lowest current velocity, which is 0.04 m³/sec. Station 4 has land use for mangrove areas.

Table 1. Physical and Chemical Parameters in the Green Canyon River Stream in September, October and November

| Parameters | Unit | | Station | | | | |
|------------------|---------------------|---------|-------------|------------|------------|------------|------------|
| | | | 1 | 2 | 3 | 4 | 5 |
| Transparency | cm | Average | 234.67±11 | 87.83±10.3 | 109.33±11 | 69.75±6 | 97.2±6.5 |
| | | Range | 168-356 | 80-99.5 | 97-112.5 | 64-76 | 90.5-103.5 |
| Temperature | °C | Average | 27.13±0.2 | 28.1±0.8 | 28.2±2.8 | 29±0.6 | 31.93±2.1 |
| | | Range | 26.9-27.3 | 27.3-29 | 25.3-31 | 28.4-29.6 | 29.8-3.4 |
| pH | | Average | 7.51±1 | 7.29±0.5 | 7.33±0.9 | 7.27±1.2 | 7.25±1.1 |
| | | Range | 6.42-8.4 | 6.72-7.69 | 6.34-7.87 | 5.94-8.05 | 5.96-8 |
| Salinity | ppt | Average | 6.67±1.5 | 8,67±4,5 | 14.33±7 | 19.67±7.5 | 28.33±7.6 |
| | | Range | 5-8 | 4-13 | 7-21 | 12-27 | 20-35 |
| DO | mg/L | Average | 9.67±3.5 | 7.4±1.6 | 7.63±1.5 | 7.7±1.1 | 7.93±0.8 |
| | | Range | 7.6-13.7 | 6.2-9.2 | 6.1-9.1 | 6.7-8.9 | 7,1-8,8 |
| Current | m ³ /sec | Average | 0.2±0.01 | 0.18±0.01 | 0.08±0.006 | 0.04±0.006 | 0.07±0.006 |
| | | Range | 0.19-0.21 | 0.17-0.19 | 0.08-0.09 | 0.04-0.05 | 0.06-0.07 |
| BOD ₅ | mg/L | Average | 3.85±0.5 | 1.19±0.4 | 3.9±0.6 | 6.18±0.5 | 3.88±0.6 |
| | | Range | 3.44-4.35 | 0.72-1.55 | 3.33-4.54 | 5.84-6.81 | 3.4-4.53 |
| Nitrate | mg/L | Average | 0.367± 0.02 | 0.72±0.23 | 0.455±0.21 | 0.176±0.09 | 0.103±0.05 |

| Parameters | Unit | | Station | | | | |
|------------|------|---------|-------------|-------------|-------------|-------------|-------------|
| | | | 1 | 2 | 3 | 4 | 5 |
| | | Range | 0.35-0.39 | 0.31-0.70 | 0.22-0.616 | 0,08-0.26 | 0.04-0,13 |
| Phosphate | mg/L | Average | 0.063±0.03 | 0.04±0.01 | 0.029±0.001 | 0.016±0.007 | 0.010±0.003 |
| | | Range | 0.023-0.099 | 0.026-0.057 | 0.028-0.03 | 0.007-0.025 | 0.006-0.015 |

The average range of BOD₅ found in the Green Canyon River flow ranges from 1.19 - 6.18 mg / L (Table 1). The highest BOD₅ concentration is found at station 4, which is equal to 6.18 with land use as a mangrove area. This is because at station 4 there is a mooring activity of the anchorage of mangrove tourism vessels and mangroves are a binding agent that is carried by the river water flow.

Nitrate concentrations in the Green Canyon River flow range from 0.044 to 0.704 mg / L (Table 1). According to Government regulations Number 82 In 2001 the station 1 quality standard was still appropriate because it did not reach 10 mg / L. As for according to Ministerial decree of Living Environment Number 51 of 2004, the standard of nitrate quality for biota and marine tourism is <0.008 mg / L. This shows that nitrate concentration in waters at stations 2, 3, 4 and 5 exceeds the threshold for marine tourism. This shows the problems in terms of tourism at stations 2, 3, 4 and 5. Handling and handling are needed to support tourism activities in the Green Canyon River.

Phosphate concentrations in the Green Canyon River flow range from 0.006-0.099 mg / L (Table 1). According to Government Regulations Number 82 In 2001 station 1 is still in accordance with quality standards because it has a concentration of less than equal to 0.2 mg / L. As for according to ministerial decree of Living Environment Number 51 of 2004 stipulates the phosphate quality standard for biota and marine tourism is <0.015 mg / L. This shows that nitrate concentration in waters at stations 2, 3, 4 and 5 exceeds the threshold for marine tourism. States that phosphate is not toxic to aquatic organisms or human health because it can be broken down through hydrolysis.

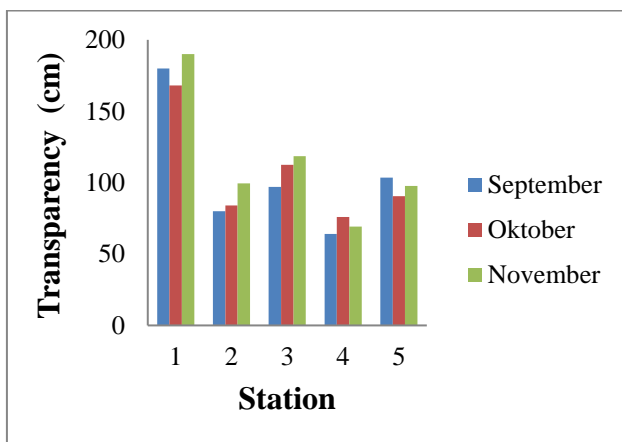


Figure 2. Transparency Graphic

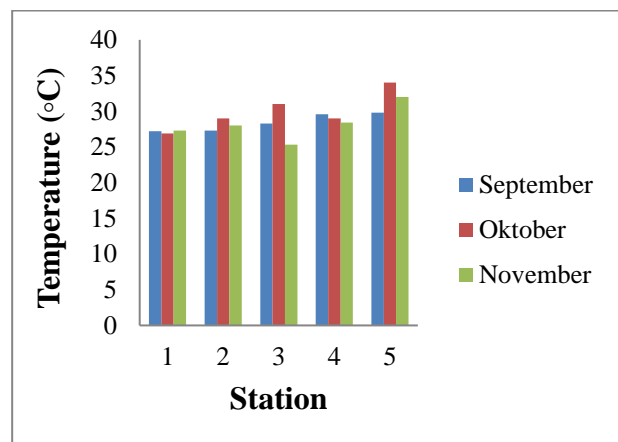


Figure 3. Temperature Graphic

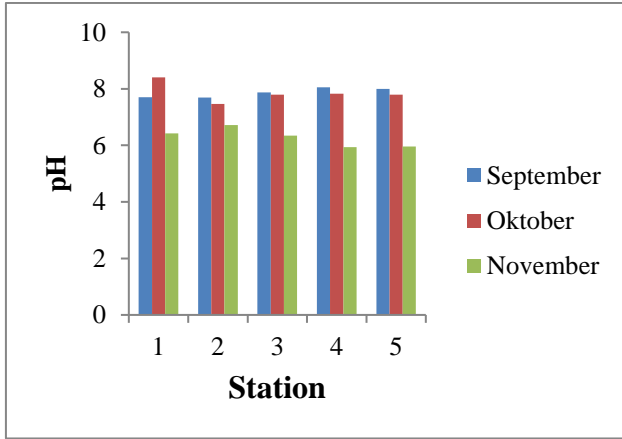


Figure 4. pH Graphic

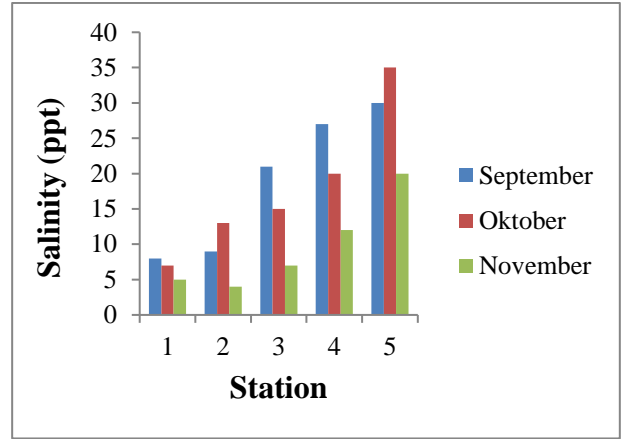


Figure 5. Salinity Graphic

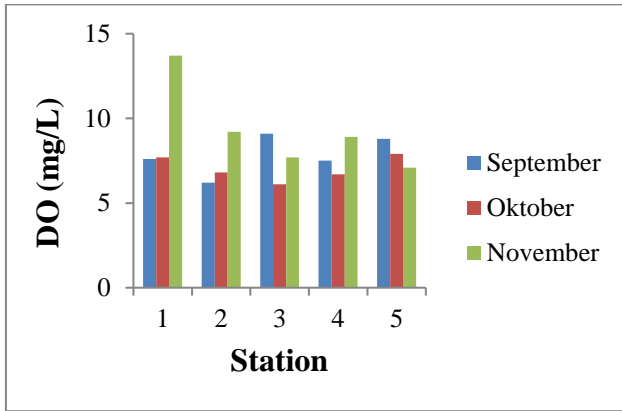


Figure 6. DO Concentration Graphic

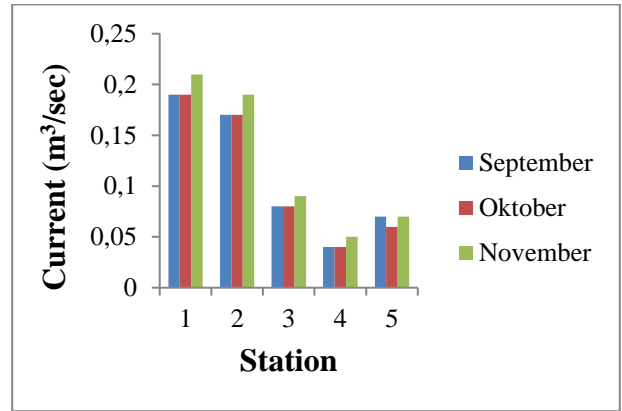


Figure 7. Current Graphic

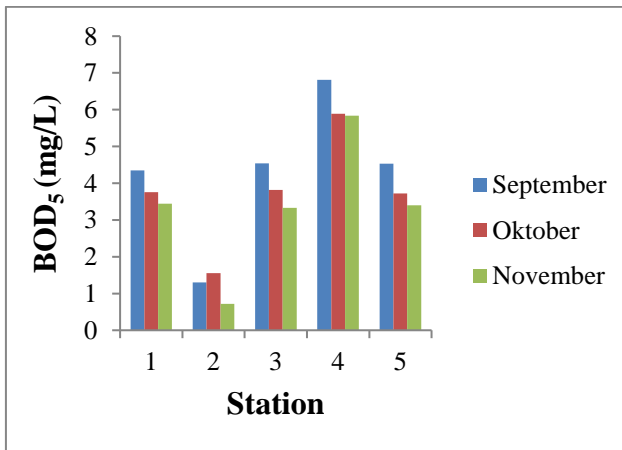


Figure 8. BOD₅ Concentration Graphic

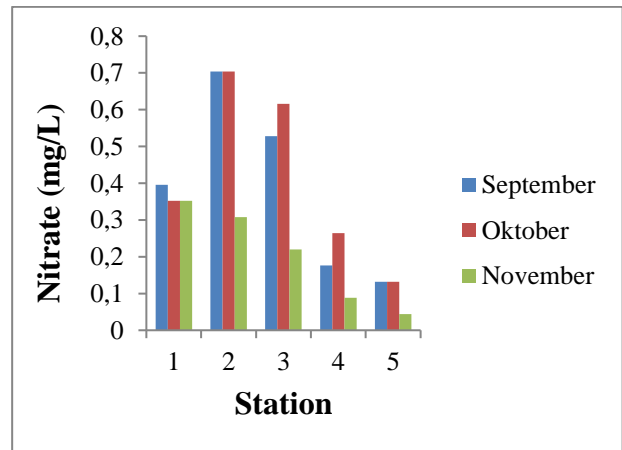


Figure 9. Nitrate Concentration Graphic

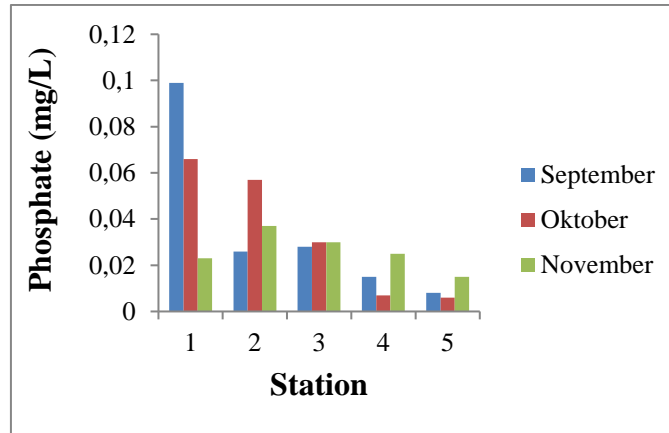


Figure 10. Phosphate Concentration Graphic

3. 2. Plankton Saprobic Index

Identification results of plankton species that were found were 84 plankton species consisting of 5 polysaprobic species, 12 α -Mesosaprobic species, 53 β -Mesosaprobic species, and 14 Oligosaprobic species. The results of the calculation of the Plankton Saprobic Index in the Green Canyon River flow range from 1 - 1.5 with the average saprobic index values ranging from 1.1 - 1.5 (Table 2). The lowest calculation of the saprobic index is at station 4 which is reinforced by the high BOD₅ value. Mentions that BOD₅ can indicate organic material derived from the decay of plants and animals that have died or domestic and industrial waste discharged in the waters. This condition correlates with land use at station 4 which is a mangrove area that has a function as a pollutant trap. State that one of the roles of mangroves is as a place to assimilate waste material. The highest saprobic index is found at station 2 with an average value of 1.5. Station 2 is the first brackish point and far from residential areas and has forest-dominated land use. The most commonly found species in the Green Canyon River are Bacillariophyceae with silicate concentrations found in the Green Canyon River range ranging from 0.01 - 0.06 mg / L (Sahidin et al. 2019).

Table 2. Saprobic Index in the Green Canyon River Stream.

| Station | Saprobic Index | | Criteria | |
|---------|----------------|---------|-----------------|-----------|
| | Range | Average | Range | Average |
| 1 | 1,1 - 1,5 | 1,3 | Mild -Very Mild | Mild |
| 2 | 1,4 - 1,5 | 1,5 | Mild -Very Mild | Very Mild |
| 3 | 1,1 - 1,5 | 1,3 | Mild -Very Mild | Mild |
| 4 | 1,0 - 1,3 | 1,1 | Mild - Mild | Mild |
| 5 | 1,0 - 1,4 | 1,2 | Mild - Mild | Mild |

Table 3. Saprobic Index in the Green Canyon River Stream.

| Pollutant | Pollutant Level | Saprobic Level | Saprobic Index |
|------------------------------|-----------------|---------------------------------|-----------------|
| Organic Matter | Very Heavy | Polysaprobic | (-3,0) - (-2,0) |
| | Heavy | Poly / α – Meso saprobic | (-2,0) - (-1,5) |
| | | α – Meso / Poly saprobic | (-1,5) - (-1,0) |
| | | α – Mesosaprobic | (-1,0) - (-0,5) |
| Organic and Anorganic Matter | Moderate | α/β – Mesosaprobic | (-0,5) - (0,0) |
| | | β/α – Mesosaprobic | (0,0) - (+0,5) |
| | Mild | β – Mesosaprobic | (+0,5) - (+1,0) |
| | | β – Meso/oligo saprobic | (+1,0) - (+1,5) |
| Organic and Anorganic Matter | Very Mild | Oligo/ β – Meso saprobic | (+1,5) - (+2,0) |
| | | Oligosaprobic | (+2,0) - (+3,0) |

3. 3. The composition of Plankton in the Green Canyon River Stream

The composition of plankton to the genus level in the Green Canyon River flow on the water surface (<0.2 m) consists of 70 plankton genera consisting of 64 phytoplankton genus and 6 zooplankton genera. Phytoplankton consists of 7 phylum and zooplankton consisting of 3 phylum.

3. 4. Biological Index Data

The results of the calculation of the largest average abundance in this research are at station 5, which is equal to 2495 individual / L (Table 3). This is because station 5 is directly adjacent to the sea and is an estuary area, so there is a lot of concentrated nutrients. Waters with many nutrients allow phytoplankton to be more optimal in utilizing them (Hasan et al. 2013). The lowest average abundance calculated in this research is found at station 2 which has a relatively heavy flow. Waters with heavy currents do not allow nutrients to be held for long periods in the waters, so abundance tends to be lower compared to waters that tend to be inundated (Hasan et al. 2013).

The average diversity index of plankton in the Green Canyon River flow ranges from 0.99 to 1.02 (Table 3). Statement of Nurruhwati et al. (2017) that the diversity of plankton which ranges from $0 < H < 2.3$ belongs to the low category. The highest diversity index value is found at station 2 which is the best station in terms of pollution levels based on the calculation of the saprobic index.

The average dominance index in the Green Canyon River flow ranges from 0.103 - 0.121 (Figure 21). Dominance index criteria, namely $0 < C \leq 0.5$, showed a low dominance level, $0.5 < C \leq 0.75$ indicating moderate dominance and $0.75 < C \leq 1$ showed a high degree of dominance (Odum 1971). Based on these criteria it can be seen that the dominance index of plankton in the Green Canyon River flow is low.

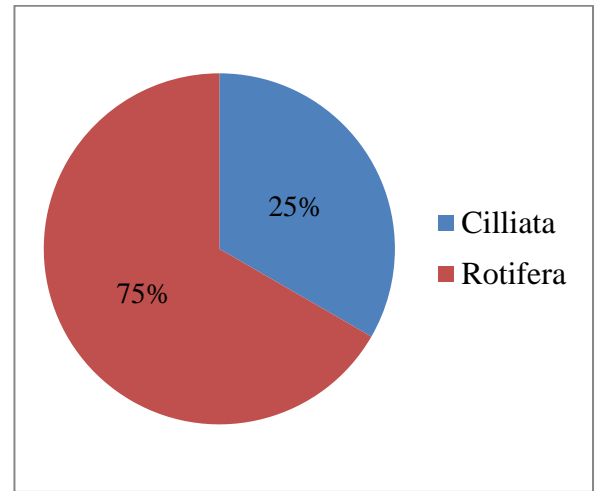
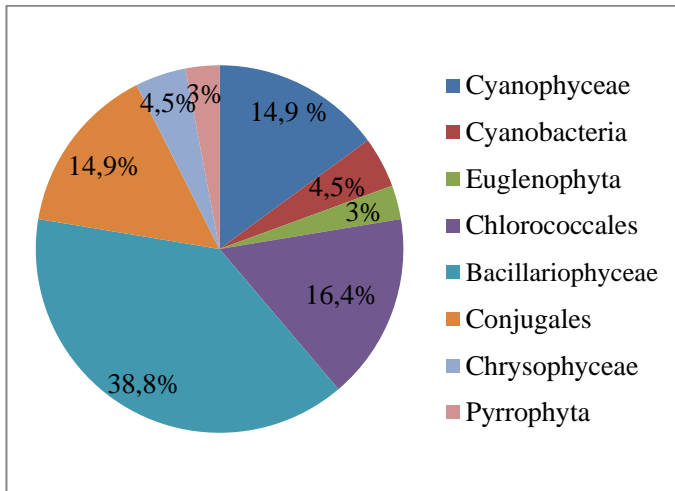


Figure 11. Phytoplankton composition in the Green Canyon River Stream

Figure 12. Zooplankton composition in the Green Canyon River Stream

Table 4. Plankton (individual/L) Average Abundance in All Stations.

| Phylum | Station | | | | |
|----------------------|---------|-----|------|-----|------|
| | 1 | 2 | 3 | 4 | 5 |
| Phytoplankton | | | | | |
| Cyanophyceae | 46 | 14 | 63 | 71 | 54 |
| Cyanobacteria | 71 | - | 38 | 10 | 58 |
| Euglenophyta | 25 | 21 | 104 | 59 | 83 |
| Chlorococcales | 304 | 57 | 121 | 49 | 100 |
| Bacillariophyceae | 1110 | 416 | 1310 | 804 | 1723 |
| Pyrrophyta | 3 | 9 | 6 | 3 | 20 |
| Conjugales | 436 | 155 | 566 | 428 | 451 |
| Chrysophyceae | - | 3 | 48 | - | - |

| Phylum | Station | | | | |
|----------------------|---------|-----|------|------|------|
| | 1 | 2 | 3 | 4 | 5 |
| Phytoplankton | | | | | |
| Zooplankton | | | | | |
| Ciliata | 6 | - | - | 3 | - |
| Rotifera | 10 | - | 9 | 11 | 6 |
| Total | 2011 | 672 | 2217 | 1438 | 2495 |

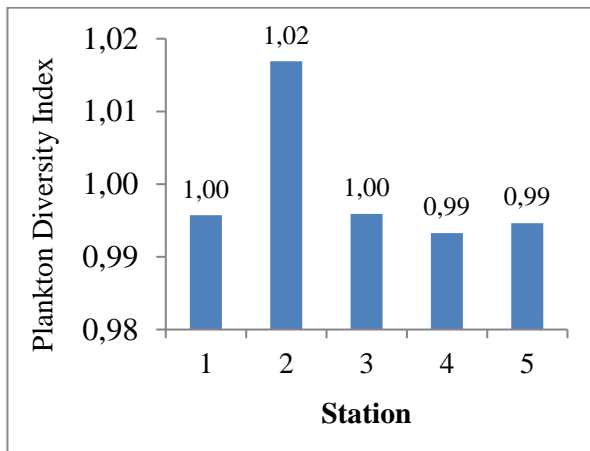


Figure 13. Plankton Diversity Index in the Green Canyon River Stream

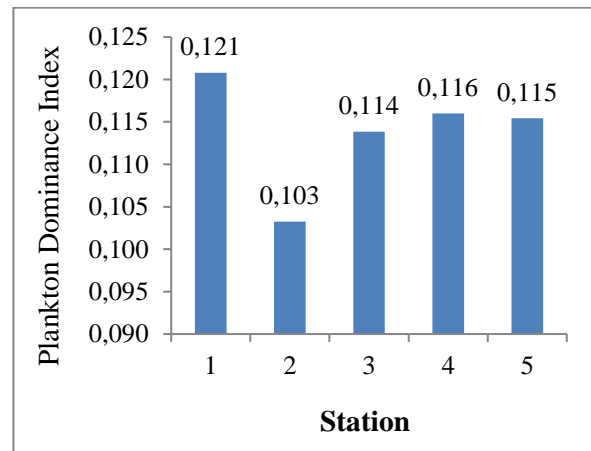


Figure 14. Plankton Dominance Index in the Green Canyon River Stream

4. CONCLUSION

The saprobic index of plankton in the Green Canyon River is in the range of 1.0 - 1.5 and is included in the β -Meso / Saprobic Oligo category which indicates that the waters are in mild to very mild polluted conditions.

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