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Structure Community of Phytoplankton as a Bioindicator of Water Quality in Situ Rawa Dongkal, East Jakarta, Indonesia

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ABSTRACT

Situ Rawa Dongkal is one of the radical urban lakes in the village of Cibubur, East of Jakarta, Indonesia. This urban lake plays a vital role in water conservation, biodiversity, nurseries and recreational facilities. Currently, Situ Rawa Dongkal is facing pressure originated from nature and human activities, causing changes in water quality. Phytoplankton as an environmental bioindicator can be used to measure the water quality of this lake. Thus, a quantitative study was conducted to address the water quality in Situ Rawa Dongkal based on chemical, physical and phytoplankton factors as a reference material on the usefulness of water for tourism. Parameters of pH, temperature, BOD, COD, DO, nitrates, phosphates and phytoplankton were measured. Sampling was conducted three times at four stations. In addition, diversity, uniformity and dominance were determined for the analysis of phytoplankton community structure. Some results of physico-chemical measurements, such as temperature, pH, nitrates and phosphates indicate a good condition, supporting the life of organisms, especially phytoplankton. While, values of BOD and COD were higher than the quality standard. 22 genera were detected from 6 classes; namely, Bacclilariophyta, Chlorophyta, Ochrophyta, Chrysophyta and Euglenophyta, with the most dominant number from the class Chlorophyta. Generally, the phytoplankton diversity values are low-medium, and the saprobity index values fall into the / - Mesosaprobic to - Meso / oligo saprobic categories. These results indicate that the Situ Rawa Dongkal ecosystem is less stable but slightly polluted, thus it is still recommended for tourism activities.

INTRODUCTION

Situ Rawa Dongkal is one of the essential urban lakes with an area of 3.8 ha, which is located in Cibubur village, East Jakarta, Indonesia. In general, the function of this lake is to collect plant seeds and tree nurseries. Situ Rawa Dongkal reflects the government's efforts to turn 30% of the Jakarta area into green open space **(Forclime, 2014)**. This ecosystem's functions include environmental buffers, water catchment areas, plant collections, green open spaces and germplasm for animal shelters. There are several types of plants, such as mahogany, trambesi, Ketapang and Angsana, which act as air filters and buffers. In addition, the *in situ* ecosystem serves as a habitat for various organisms, both flora and fauna. Furthermore, fish, aquatic insects, and crustaceans such as shrimp and benthos are found in this habitat **(Forclime, 2014)**.

Situ Rawa Dongkal, besides playing an essential role in the water ecosystem, the green open space also acts as a tourist recreation area. For tourists, it is a place for fishing and enjoying the scenery. Generally, those who visit this place are either residents or living in East Jakarta. **Permata *et al*. (2018)** stated that people around the location generally visit Situ Rawa Dongkal. The average number of domestic tourists is 1500. The high number of visitors, especially in the weekends, is feared to affect the lake's ecosystem, and increase the level of pollution entering the water. In this context, **Ramadhan *et al*., (2016)** reported that, increasing tourism visits to the Situ Gunung ecosystem would increase the pollutant load on the waters and subsequently water quality decreases.

Phytoplankton are aquatic organisms that floating on the surface of water and are microscopic in size. Phytoplankton can be used as an indicator of change and productivity of waters **(Hutabarat *et al*., 2014).** According to **Bazhenova and Krentz (2018)**, phytoplankton are the easiest object to observe and assess water quality as biomonitoring because it reacts quickly to external influences. These organisms can efficiently respond to environmental changes and are commonly used to evaluate ecological changes and reflect significant system interactions **(Wu *et al*., 2019; Ali and Shehawy, 2017)**. Generally, phytoplankton can be used as bioindicators of water quality. The high and low value of the phytoplankton community structure can describe the water quality so that it can determine and recommend whether the waters are still suitable for tourist attractions **(Lathifah *et al*., 2020).**

As an ecosystem with tourism potential, it is necessary to monitor water quality and whether the ecosystem is feasible to become a tourist place based on Government Regulation number 22 of 2021. Water quality assessment can be carried out through physical, chemical and biological parameters. One of the standard biological parameters used is the determination of phytoplankton composition quantitatively and qualitatively that reflecting as a bioindicators for determining water quality. The purpose of this study was to determine the assessment of water quality by using phytoplankton community-based tourism.

MATERIALS AND METHODS

1. Study and time area.

This research was conducted in January – February 2022 in Situ Rawa Dongkal with coordinates 06^{o}23'06" and 106^{o}45'11". Situ Rawa Dongkal is located in Cibubur Village, Ciracas District, East Jakarta City. This research method is quantitative, namely by taking water quality and phytoplankton community structure.

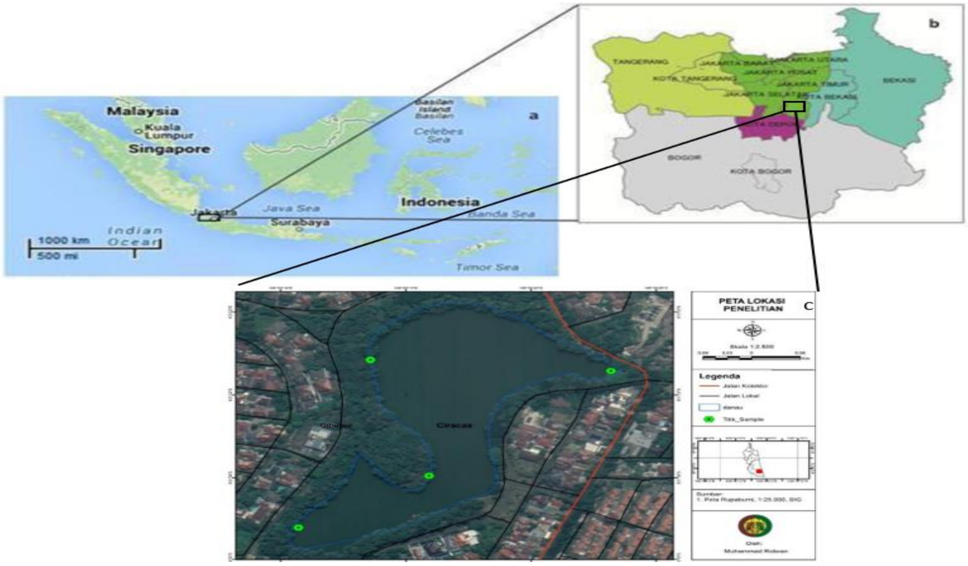

Fig. 1. Location and the regions of megacity Jakarta (a) Indonesian map by Google Map, 2103; (b)Jabodetabek map originated from Mimura (RIHN project researcher, 2013); (c) self creation map

The chemistry-physical collection of water in Situ Rawa Dongkal was carried out by observation. Observations were made to observe and analyze the condition of the research area. There are four stations in sampling, this determination is made using purposive sampling which is adjusted to the ability and condition of the researcher in sampling. The stations are inlet, outlet, midpoint and tourist area. Sampling of water and phytoplankton at each point was carried out three times.

2. Tools and Materials

In this study the tools used were thermometer, spectrophotometer, DO meter, pH meter, plankton net 25 micrometer, sample bottles, microscope, *cool box*, 5 L bucket, worksheet and tissue. Meanwhile, the materials used are aquadest, water samples, 4% formalin, and the plankton identification book refers to *Marine Plankton* **(Newell & Newell, 1977).**

3. Data Collection Techniques Sampling

Sampling of plankton and water samples was carried out by taking 100 liters of water which was then filtered using a plankton net measuring 25 micrometer . The 100 liters of water sample was then filtered and put into a 500 ml sample bottle (PE) which was then given 4% formalin. The sample bottles were then labeled **(Hidayat *et al*., 2014; Saragih and Erizka, 2018)**. Then for the measurement of the chemical-physical parameters of water carried out directly in the field using temperature, while other parameters used DO, BOD, COD, pH, TSS, Nitrate and Phosphate measured in the laboratory. After all sampling is complete, the sample is then analyzed at the PT. Unilab, Jakarta.

4. Mathematical ecological analysis

Data analysis from this study includes diversity, uniformity index, dominance index. The abundance of plankton uses the following formula:

Shannon-wiener Index Of Diversity (H)

Diversity of plankton using the Shannon-Wiener formula as follows:

$$H' = \sum \frac{ni}{N} ln \frac{ni}{N}$$

Information :

H' : Species Diversity Index

Ni : Number of individuals of each species

N : Total number of individuals of all species

With the criteria of diversity index value:

H' < 1 : Unstable biota community or heavily polluted water quality

1 < H' < : Moderate biota community stability or moderately polluted water quality

H' > 3 : Biota community stability in prime condition or clean water quality

Uniformity index (E)

The uniformity index (E) is calculated based on the species uniformity index as follows:

$$E = \frac{H'}{\ln S}$$

Information :

E : Species uniformity index

H' : Diversity index

S : Number of species

With the uniformity value criteria:

E = 0 : The uniformity between species is low

E = 1 : The uniformity between species is relatively uniform

Dominance Index (D)

This index is used to determine the dominance of certain species in the waters, the Simpson dominance index can be used with the following equation:

$$D = \left(\frac{ni}{N}\right)^2$$

Information :
D : This dominance index
ni : Number of individuals of each species
N : Total individuals

Saprobity index (S)

Saprobity index analysis is used to find out how much pollution there is in a waters. The calculation of the aquatic saprobity index used TROSAP analysis whose value was determined from the results of the formulation of **Anggoro (1988) in Suryati (2008)**

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

Description:
A : Number of genera/species of organism polysa probic
B : Number of genus/species of organism –mesosa probic
C : Number of genus/species –mesosa probic organisms
D : Number of genera/species of oligosaprobic organisms

Table 1. Saprobity Index through Biological Interpretation of Water Quality

Pollution load	**Degree of pollution**	**Saprobic Phase**	**Saprobic Index**
Many Organic Compounds	High	Polisprobic	-3.0 to -2.0
	Medium high	Poli /α - Meso saprobic	-2.0 to -1.5
		α – Meso/Poli saprobic	-1.5 to -1.0
		α – Mesosaprobic	-1.0 to -0.5
Organic and Inorganic Compounds	Medium	α / β – Mesosaprobic	-0.5 to 0.0
		β / α - Mesosaprobic	0.0 to +0.5
	Light / Low	β – Mesosaprobic	+0.5 to +1.0
		β - Meso / oligo saprobic	+1.0 to +1.5
	Very light	Oligo / β – Meso Saprobic	+1.5 to +2.0
		Oligosaprobic	+2.0 to +3

RESULTS AND DISCUSSION

1. Phytoplankton Community Structure and Species Composition:

Based on the results of the study found 22 genera from 6 classes, namely Bacclilariophyta (there are 2 genera namely *Synedra* sp. and *Achnanthes* sp.*)*, Chlorophyta (there are 13 genera namely *Ankistrodesmus* sp., *Chlorella salina*, *Haematococcus* sp., *Monoraphidium griffithii*, *Spirulina* sp., *Pediastrum* sp., *Pediastrum tetras*, *Scenedesmus acuminatus*, *Scenedesmus* sp., *Selenastrum* sp., *Stipitococcus* sp., *Spirulina* sp., *Xanthidium* sp.*)*, Ochrophyta (1 genus, namely *Amphipleura* sp.), *Charophyta* (2 genera namely *Staurastrum dejectum* and *Closterium* sp.), Chrysophyta (2 genera namely *Navicula* sp. and *Ochromonas* sp.), Euglenozoa (2 genera namely *Euglena* sp. and *Phacus* sp.)

Table 2. Types of phytoplankton in Situ Rawa Dongkal

Class	**Genus**	**(%)**
Bacclilariophyta	*Synedra* sp.	0.002
	Achnanthes sp.	0.010
Chlorophyta	*Ankistrodesmus* sp.	0.002
	Chlorella salina	0.025
	Haematococcus sp.	0.007
	Monoraphidium griffithii	0.881
	Spirulina sp.	0.002
	Pediastrum sp.	0.007
	Pediastrum tetras	0.002
	Scenedesmus acuminatus	0.003
	Scenedesmus sp.	0.003
	Selenastrum sp.	0.002
	Stipitococcus sp.	0.002
	Spirulina sp.	0.002
	Xanthidium sp.	0.002
Ochrophyta	*Amphipleura* sp.	0.033
Charophyta	*Staurastrum dejectum*	0.002
	Closterium sp.	0.005
Chrysophyta	*Navicula* sp.	0.007
	Ochromonas sp.	0.002
Euglenophyta	*Euglena* sp.	0.002
	Phacus sp.	0.002

Composition of phytoplankton based on the location of the research station:

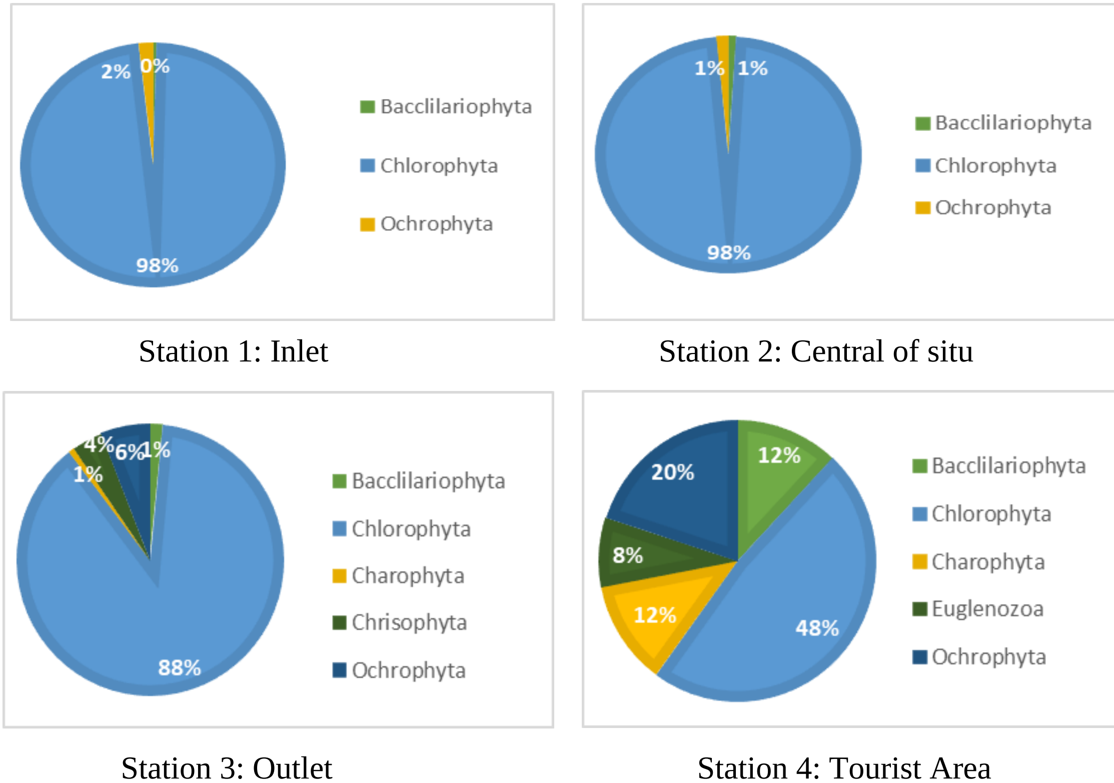

Fig 2. Composition of phytoplankton as a percentage in Situ Rawa Dongkal

Based on the results of this study, it is known that the Chlorophyta class has a number that dominates other classes, respectively 98%, 88% and 48%. The first and second stations, namely Inlet and Central Situ, have the same percentage of 98%. At the third station, namely the outlets, the percentage is slightly lower at 88%, while at the fourth station, namely the tourist area, the percentage is deficient at 48%. From the results of this study, the most abundant species was *Monoraphidium griffithii*, with a total of 535 individuals. The types of phytoplankton belonging to the class Chloropyhta are species that can grow well in sufficient light conditions. Generally, these types are found in water ponds with good light intensity, such as lakes or lakes **(Maresi *et al*., 2015; Zikriah *et al*., 2020)**. According to **Ananda *et al*., (2019)** that Chloropyhta can be found in large populations because of its good ability to breed and adapt, cosmopolitan nature, can be found in various habitats and has a high abundance of individuals **(Purba *et al*., 2019; Sidomukti and Wardhana, 2021).**

Fig 3. Species Phytoplankton *Monoraphidium griffithii*

In other classes such as Bacclilariophyta, Ochrophyta, Charophyta, Chrysophyta and Euglenophyta, the percentage is lower than Chlorophyta. This low percentage is due to physical and chemical changes in water bodies. The changes of physical and chemical environment such as temperature, brightness, depth, dissolved oxygen, pH, BOD and nitrate and phosphate content affect the abundance of phytoplankton on a body of water **(Hidayah *et al*., 2014; Banerjee *et al*., 2018).**

2. Physicochemical parameters

The presence of phytoplankton in a body of water is influenced by the physico-chemical conditions of the water. In this study there are several important parameters taken such as temperature, pH and total suspended solids (TSS) for physical parameters and BOD, COD, DO, Nitrate and Phosphate for chemical parameters. The following are the results of the measurement of the physical and chemical parameters:

Table 3. Results of measurement of physicochemical parameters:

No	**Paramater**	**Unit**	**Average Result**			
			Inlet	**Outlet**	**Central**	**Tourist Area**
Physical						
1	Temperatur	^{o}C	29.1	28.8	29.3	27.3
2	Total Suspended solid (TSS)	mg/L	101	99	99	117
Chemical						
1	Biochemical Oxygen Demand	mg/L	29.2	27	27	29

	(BOD)					
2	pH	-	7.9	7.2	6.5	7.6
3	Dissolved Oxygen (DO)	mg/L	0.73	0.9	0.9	0.8
4	Chemical oxygen Demand (COD)	mg/L	37	41	52	55
5	Nitrate (NO3-N)	mg/L	<0.1	<0.1	<0.1	<0.1
6	Total Phospate	mg/L	0.19	0.08	0.08	0.7

The quality and criteria of water quality are a standard basis for water quality requirements that can be utilized. Water quality evaluation is very important for water resources management. Water quality is influenced by chemical factors such as BOD, COD, pH, nitrate, phosphate, DO and physical factors such as temperature and TSS.

BOD is one of the indicators and chemical factors of water that can be used to determine the level of water pollution from a pollution source **(Hamuna *et al*., 2018).** BOD concentration indicates the oxygen requirement of micro-organisms to decompose organic compounds contained in the waters **(Yohannes *et al*., 2019)**. COD is a parameter for estimating the total amount of organic matter present in water or waters, both easy to decompose and difficult to decompose **(Atima, 2015).** COD analysis is to determine the amount of oxygen needed to oxidize organic compounds chemically. Chemical Oxygen Demand (COD) is the amount of oxygen needed to oxidize organic substances in 1 liter of a water sample, where the oxidizer K2Cr2O7 is used as a source of oxygen (oxidizing agent) **(Sulistia and Septisya, 2019)**. Several factors that influence the level of COD in waters are organic substances, dissolved oxygen and water pollutants **(Lusiana *et al*., 2020).**

DO is a parameter that is very influential on the life of aquatic organisms. One of the factors that affect dissolved oxygen is the atmosphere. Decreasing dissolved oxygen levels have a tangible impact on aquatic living things **(Noumy *et al*, 2016).** Dissolved oxygen has a parameter value opposite to other water parameters, the lower the dissolved oxygen value, the more polluted the water conditions **(Yohannes *et al*., 2019).** Based on the measurement results, the DO value from there is below the standard or, in other words, does not support the life of aquatic biota. One factor that affects the level of dissolved oxygen is temperature, pressure and ion concentration. The low value of dissolved oxygen is also due to the high total suspended solids (TSS) in the water that exceeds the standard quality value. This causes low sunlight to enter the water body, thus disrupting the photosynthesis process **(Soliha and Rahayu, 2018).** The high value of

TSS will directly inhibit the entry of sunlight into the water body. This will inhibit the growth and development of aquatic organisms, especially phytoplankton **(Winarsih *et al*., 2016)**. Another factor that makes the DO value low is the large number of leaves that fall into the water, which causes decomposition. According to research by **Sawitri and Takandjandji (2019)**, the decrease in DO in the lake is caused by the decomposition of organic matter from dead aquatic plants.

pH or the degree of acidity is highly correlated with the content of heavy metals in waters. The low pH value is due to many pollutants, such as heavy metals, which will cause the water to become more acidic. Variations in the pH value of the waters significantly affect the biota in the waters. The high pH value greatly determines the dominance of phytoplankton which will then affect the level of primary productivity of waters where the presence of phytoplankton is supported by the availability of nutrients in marine waters **(Megawati *et al*., 2014)**. Based on the measurement results, the pH value from there is still good for the life of aquatic biota, which is still in the range of 6-9. According to **Yuliana (2007)**, the pH value that supports phytoplankton life is 6.5-8.0. The same thing was also expressed by **Sahidin *et al*., (2019)** that the pH value that supports the productivity of phytoplankton is in the range of 6 -7.

Nitrate is the result of nitrogen oxidation in water which is influenced by dissolved oxygen concentration **(Merina and Zakaria, 2016; Haris *et al*., 2019)**. At the same time, phosphate is a nutrient content that describes the level of fertility of nutrients in waters. Nutrients influence nitrate content in waters from agriculture and fish farming **(Zulfiah and Aisyah, 2016)**. Nitrates and phosphates play an essential role in the life processes of organisms in the water. These two nutrients play a role in the growth and development of biota, such as the formation of tissue cells of living organisms **(Paiki and Kalor, 2017)**. According to **Nasution *et al*., (2019)**, the amount of phytoplankton in waters is influenced by the concentration of nitrate and phosphate, both of which can be used as indicators to distinguish the high and low abundance of phytoplankton in the waters.

Based on the research results, the phosphate value is 0.08 – 0.7 mg/L. Based on the results of this measurement, the phosphate values of the three research stations are below the quality book, except for the tourist area stations. According to **Suwoyo *et al*., (2020)**, the optimum phosphate value for the life, growth and development of phytoplankton is a value of 0.27 – 5.51 mg/L. This phosphate value illustrates that many phytoplankton use phosphate as a source of nutrients for growth **(Sahidin *et al*., 2019)**, besides the low phosphate value means low water fertility. Based on the results of this study, the nitrate value of the four research stations was <0.1. This value is below the quality book standard, which means the value is still safe for phytoplankton. The low value of nitrate at each station is due to the absence of materials that contain nitrate. One of the ingredients that contain nitrate is feed residue from fish feed, where the remaining feed can play a role in enriching nitrate (NO3)in water bodies **(Junaidi *et al*., 2019)**.

Temperature is a physical parameter that has a role in the material cycle and affects the waters' physical, chemical and biological properties. According to **Riza *et al*., (2015)**, the temperature has a role in influencing chemical properties in waters such as dissolved oxygen, respiration of aquatic biota, speed of chemical reactions and degradation of pollutants. Based on the results of temperature measurements, it is known that the temperature values range from 27-28^{o}C. This indicates that the temperature at the research site still meets the standard for the life of aquatic organisms.

3. Community structure of Phytoplankton

Phytoplankton community structure based on mathematical ecological parameters

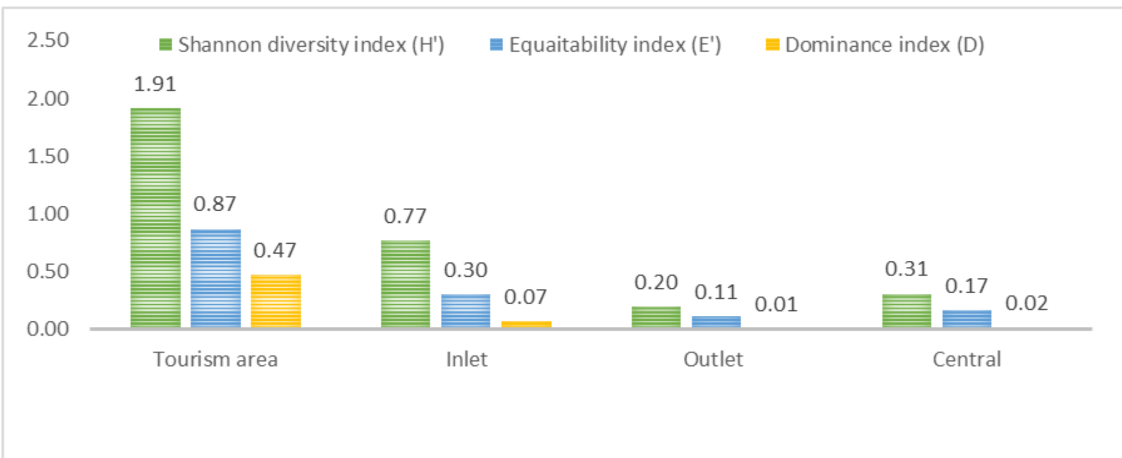

Fig 4. Structure community Phytoplankton in Situ Rawa Dongkal

The phytoplankton community structure plays an important role in describing the water quality. This value describes the pressure, stability, and disturbances in aquatic ecosystems **(Sentosa *et al*., 2018; Hidayat *et al*., 2019)**. Several important components such as salinity, depth, nutrients, mixing of water masses, temperature, wind and currents have a role in differences in plankton communities in waters **(Kostryukova *et al*., 2018)**. Based on the results of this study, it is known that only tourist area stations have the highest diversity (H'), Uniformity (E) and Dominance (D) values compared to the other three stations. This is reinforced by the number of species and abundance at that station which is higher than the others. From the results of this measurement, only tourist area stations have better water quality or, in other words, moderate community stability, while the other three stations are in the unstable category. At the same time, the results of the uniformity index measurement obtained a low value.

The results of research conducted by **Bagaskara *et al*., (2020)** show that a high uniformity index describes the stability of the community, while the results of this study show the opposite. This low uniformity value indicates that the genus composition distribution level in a population is very much different/non-uniform. Based on the dominance index measurement results, almost all of the research stations have a value close to 0. This indicates that there is no species dominance. However, the dominance value is higher at tourist area stations, namely 0.47. This value describes the type of phytoplankton that is more abundant than the others. It is known that the dominant species at this station is *Chlorella salina.* According to **Ramadhan *et al*., (2016)**, the abundance of individuals of a species is due to Physico-chemical factors in waters that are suitable for phytoplankton life.

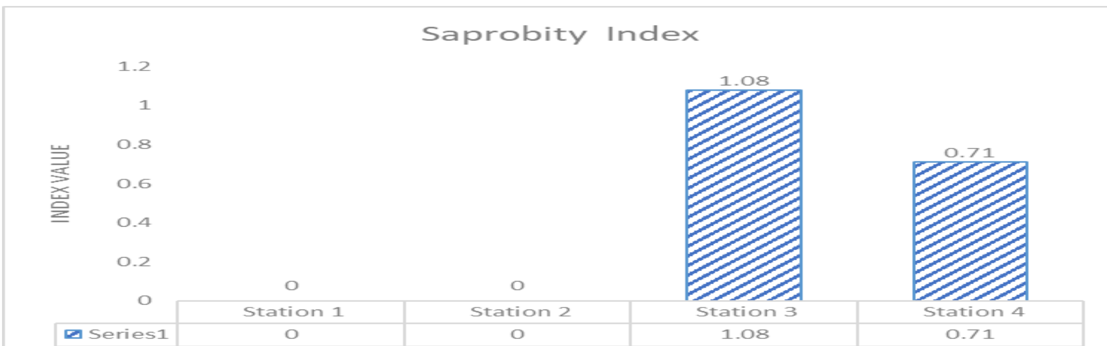

Fig 5. Saprobity index

Based on the measurement results, the value of the aquatic saprobity index ranges from 0 to 1.08. The highest value at the third station is 1.08 at the inlet, followed by the 4th station, namely the tourist area, with a value of 0.71. Meanwhile, at stations 1 and 2, the saprobic value is 0. In general, the saprobic value in water is influenced by several things, such as the proximity of water bodies to human settlements, sedimentation, and organic and inorganic pollutants **(Ilham *et al*., 2020)**. Overall, the saprobic value of Situ Rawa Dongkal waters is included in / - Mesosaprobic to - Meso / oligo saprobic. This illustrates that the waters are still excellent and have minimal pollution. This value shows that the waters of Situ Rawa Dongkal are still good and support the life of aquatic organisms in tourism activities. Based on the results of research conducted by **Lathifah *et al*., (2020)**, the/α-Mesosaprobic saprobic value in Rawa Pening Lake shows light pollution, so the quality is still suitable for use for tourism activities. Another study by **Rizqina *et al*., (2018)** found that the saprobity index in Pari Island waters is classified as mild to moderate pollution. This is because there is still minimal anthropogenic activity and optimal sunlight at that location. It affects the photosynthesis of phytoplankton and produces sufficient nutrients. So that the condition of the waters still looks relatively clean and not much polluted.

CONCLUSION

Water quality based on physical and chemical measurements such as temperature, pH, DO, nitrate and phosphate are still good and follows second-class quality standards for water recreation facilities/infrastructure. While other parameters such as BOD, COD and TSS show values above the quality standard, water quality improvements are needed so that the BOD and COD values decrease, one of which is by building a simple WWTP around it. In general, the phytoplankton community structures such as diversity (H'), uniformity (E) and dominance (D) at the study site were at low to moderate values , and certain species and the absence of harmful phytoplankton such as Harmful algae bloom (HAB) species were dominant. Meanwhile, the value of the saprobic index showed a / – Mesosaprobic to - Meso / oligo saprobic phase with a light pollution degree. It can be concluded that the waters of Situ Rawa Dongkal are still suitable for tourism activities.

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