Monitoring of water quality with the plankton indicator and the saprobic index in a minapadi area

[1]Zaenal A. Siregar, [1]Hari E. Irianto, [2]Sutrisno Anggoro, [3]Hartuti Purnaweni

[1] Research Center for Maritime and Land Bioindustry, National Researh and Innovation Agency, Lombok, Indonesia; [2] Faculty of Fisheries and Marine Science, Diponegoro University, Semarang, Indonesia; [3] Department of Environmental Science, School of Doctoral Studies, Diponegoro University, Semarang, Indonesia. Corresponding author: Z. A. Siregar, zaienal1985@gmail.com

Abstract. Although the use of minapadi is a method for meeting the growing demands of humanity, the research on the culture ponds' water quality is limited. The investigation will assess the pollution in a minapadi region from February to May 2020, by employing plankton population saprobic indicators. Five sampling locations were chosen on the basis of input, water availability in the minapadi area, and output. Ex situ and in situ sampling are conducted monthly at the minapadi location. The data gathered encompassed physical, chemical, and species diversity of plankton. An examination is conducted related to the evenness (E) and dominance (D) of the plankton species. In the studied minapadi area, Bacillariophyta, Charophyta, Chlorophyta, Cyanophyta, and Euglenophyta are the phytoplankton phyla. The value of E was 0.76 in March and 0.69 in May. In March, the environment is stable or balanced, whereas in other months, the water is turbulent. H' peaked in May (1.40) and it was the lowest in February (1.03). The dominance index reached its highest point of 0.45 in February and 0.35 in March. There is no dominant species of plankton in the water. The saprobic index has the potential to provide insights into the nature and quantity of contaminants that reach the water. The minapadi area experienced a moderate level of contamination from organic and inorganic pollutants from February to May (saprobic quotient: 0.74-1.00, saprobic index: 1.74-2.01). The minimal impact of minapadi on the neighboring water quality can be attributed to its physical and chemical characteristics.

Key Words: dominance, evenness, plankton, saprobic quotient.

Introduction. Food production techniques are evolving to fulfill human needs. This is due to an increase in the amount of food consumed by humans (Tieri et al 2020). Rice field ecosystems are also important for an economy's productivity, biodiversity, food security, and fisheries, all of which have consequences for the national and local planning and policy (Freed et al 2020). Exploring land use for conservation agriculture (CA) as a potential solution to the problem is a possible approach (D'Souza & Mishra 2018). The integration of fish and rice production, or minapadi, is a method of an expanding popularity (Siregar et al 2020). Minapadi strives to maximize the space utilization while cultivating rice. The fish and paddy integration method was incorporated into the cultural identity of the world in 2005 (Lu & Li 2006).

Ongoing research regarding minapadi may now focus more on social, environmental, economic, and technological issues (such as rice and fish aquaculture). In economics research, comparing incomes, analyzing crop farming businesses, and studying minapadi farming are all crucial subjects (Ariska 2020; Syaukat & Julistia 2019). Environmental research conducted by minapadi focuses on ecological concerns, in particular the significance of methane production, and the consequences of fertilizer application (Mahmudiyah & Soedradjad 2018; Nugroho et al 2017). Minapadi waste has received little attention thus far. Indeed, the application of fertilizer to rice fields devoid of fish may result in water pollution (Firth et al 2020; Islam et al 2020). Water may become contaminated due to the feeding methods utilized in agricultural fish farms (Kibuye et al 2020; Paena et al 2017).

Due to the fact that both rice cultivation and fish aquaculture require water, the two can coexist in minapadi. Water is a habitat for various forms of life. Phytoplankton and other aquatic organisms have the potential to function as good indicators of water quality (Elshobary et al 2020; Wilhm & Dorris 1968). Plankton has been extensively utilized as a bio indicator of water quality (Hariyati & Putro 2019; Hidayat et al 2019). Plankton presence lays the groundwork for saprobic analysis, which determines the water quality with the saprobic index (SI) (Persoone & De Pauw 1979). SI is extensively used to quantify river water quality (Kaur et al 2021; Kovács et al 2018), estuary water quality (Cahyaningtyas et al 2013), and agricultural water quality (Burdon et al 2019).

To assess the effect of minapadi pollution, a study on the changes in water quality induced by minapadi is required. This is critical in determining the most appropriate environmental policy. As a consequence, this minapadi water quality study has been conducted on a periodic basis using the saprobic index.

Material and Method

Description of the study sites. The study was performed between February and May 2021 in Samberembe, Sleman, and Yogyakarta, Indonesia, due to the dry weather, such as in Figure 1. Researchers chose Sleman Regency in Yogyakarta as the study's location because it was a region capable of developing Integrated Fish Farm (IFF) as a test program for the practice (Syaukat & Julistia 2019). Samberembe is one of minapadi's pioneering settlements. The site of the sampling station 1 (SS1) is set around the latitude -7.6709155°, longitude 110.397662°, and elevation 374 m and drew its water from the Boyong River. The water flows from SS1 into the next area to meet the minapadi's water needs. The site of the sampling station (SS2) is operated at the latitude -7.67047222°, longitude 110.39777778°, and elevation 378 m as a minapadi site, at south of the water supply. SS2 stores water to meet the needs of rice crops and fisheries. The site of the sampling station 3 (SS3) is set at the latitude -7.67097222°, longitude 110.39777778°, and elevation 373 m, as a minapadi rice field, north of the water supply. SS3 water is a combination of SS1 and SS2 waters. The site of the sampling station 4 (SS4) is situated near the farmhouse, at the latitude -7.67138889°, longitude 110.39777778°, at an elevation of 368 m. The site of the sampling station 5 (SS5) is located at the latitude -7.67122222°, longitude 110.39722222° and elevation 369 m, and serves as collector of the volume of water released.

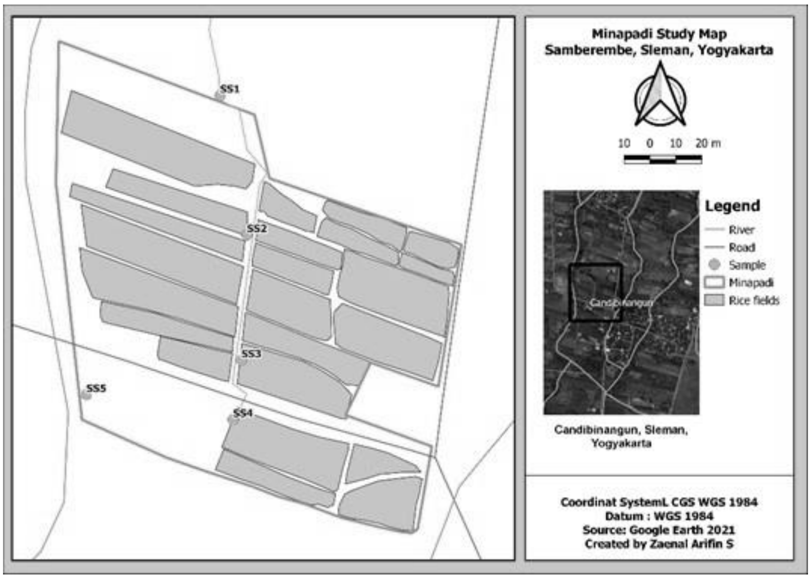

Figure 1. The sampling sites in the integrated fish farm.

Data collection. At the research site, this study measured physical parameters such as temperature and pH; chemical parameters, total dissolved solids (TDS), total suspended solids (TSS), chemical oxygen demand (COD), dissolved oxygen (DO), biochemical oxygen demand (BOD), phosphate, iron (Fe), nitrate, nitrite, and ammonia) (Hidayah et al 2021). Two sample were collected for the laboratory, the first for physical parameters, in a 2 L polyethylene and the second for the plankton specimens, resulted from 20 L of water filtered with a 200 μm. 50 mL of the filtrate was placed in a 0.05 L polyethylene bottle. The plankton sample was mixed with 1 mL of liquid treated with 10% formaldehyde (Vaschetto et al 2021). Temperature, pH and DO were measured in situ, and the other parameters were measured in the laboratory.

Analysis. Plankton is a sensitive indicator of ecosystem changes. Testing its composition is crucial for the water quality assessment. The standard method specifies the appropriate techniques and procedures for collecting, preserving, and identifying the plankton samples. The analysis used the Simpson Dominance Index (D), the Shannon Wiener Diversity Index (H'), and the Evenness Index (E) to assess the phytoplankton population dynamics (Odum & Barrett 2005). Additionally, to assess the water quality based on the Saprobic Index (SI). Using the following equation (Magurran 1988), D was calculated as:

$$\mathrm{D} = \sum \frac{n_i}{N}$$

Where:
n_i - the number of individuals belonging to a particular taxon i;
N - the total number of individuals in the sample.

Shannon Wiener Diversity Index (H') was calculated using the following equation (Magurran 1988):

$$\mathrm{H}' = -\sum pi \ln pi$$

Where:
Pi - the ratio of individual species i (n_i) to the total number of individuals (N).

The evenness Index (E) was calculated based on the following equation (Magurran 1988):

$$\mathrm{E} = \frac{\mathrm{H}`}{\mathrm{H}`_{\mathrm{max}}}$$

Where:
E - the evenness index;
H' - the Shannon-Wiener index;
H'_{max} - the upper limit of H', which may be likened to the natural logarithm of the number of species (ln s) and s represents the total number of species.

The saprobic system measures water pollution by examining its living organisms and pollution levels, and it studies prokaryotes, lower algae, protozoans, higher plants, and vertebrates (zoos, phytobenthos, and aquatic bottom organisms are the primary diets of the saprobic system) (Zahradkova & Soldan 2008). The saprobic system utilizes the saprobic quotient (SQ) and saprobic index (SI) to evaluate water quality by analyzing the organisms present in it. The SQ was determined based on the following formula (Dresscher & Mark 1976):

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

Where:
A - the total number of poly-saprobic species;
B - the total number of α-mesosaprobic species,
C - the total number of β-mesosaprobic species;
D - the total number of oligosaprobic species.

Additionally, the SI was calculated using the formula (Persoone & De Pauw 1979):

$$SI = \frac{\sum s.h}{\sum h}$$

Where:
s - the degree of saprobic, the indication parameter for every species;
h - the frequency of every species seen.
The scale for the ranges s is from 1 to 4, representing oligosaprobic indicators (s=1), β-mesosaprobic indicators (s=2), α-mesosaprobic indicators (s=3), and polysaprobic indicators (s=4) (Persoone & De Pauw 1979).

Results

Parameters of physical and chemical nature. Table 1 contains the physical parameters data (temperature, TDS, and TSS) for the minapadi region. Temperature was 27°C in February, 26.9°C in March, 27.9°C in April, and 27.9°C in May. Each month's temperature was calculated using the average temperature at each sample site, from February through May, temperatures ranged between 26°C and 30°C. The SS5 recorded the coldest temperatures in March, while the hottest temperatures reached 29°C in April and May. The TDS levels were 94.43, 89.00, 89.24, and 89.24 mg L^{-1} respectively, from February through May. TDS measurements revealed that the waters in the minapadi region remain compatible with the national water quality standard class 3, which is equivalent to 1,000 mg L^{-1} (Government Regulation No. 22 2021). TDS is a quantitative determination of the total solids (organic and inorganic) dissolved in a sample (Brraich & Saini 2015). TDS in water may be caused by household waste and agricultural runoff. Water may be categorized as fresh or saltwater based on its TDS level (Government Regulation No. 22 2021; Singh et al 2021). Between February and May, TSS levels were 5.46, 19.41, 62.64, and 62.64 mg L^{-1}. TSS data revealed that the waters in the minapadi region remain compatible with the national water quality standard class 3, which is equivalent to 100 mg L^{-1} (Government Regulation No. 22 2021). TSS is mostly formed as a result of physical processes triggered by the fish processing and by the erosion of nearby soil surface, releasing colloids (Butler & Ford 2018).

Table 1
Physical and chemical characteristics of water in the minapadi area from February to May 2021

Parameter	*Unit*	*February*	*March*	*April*	*May*
Temperature	˚C	27.16±1.10	26.98±1.48	27.98±1.02	27.98±1.02
TDS	mg L^{-1}	94.40±3.04	89.00±1	89.20±4.14	89.20±4.14
TSS	mg L^{-1}	5.40±6.06	19.40±10.57	6.00±2.64	6.00±2.64
COD	mg L^{-1}	18.00±6.49	21.84±11.04	23.54±5.60	23.54±5.60
BOD	mg L^{-1}	2.98±1.71	2.84±0.80	2.42±0.64	2.42±0.64
DO	mg L^{-1}	6.82±1.12	6.82±0.87	7.22±0.61	7.22±0.61
Iron	mg L^{-1}	0.18±0.03	0.42±0.14	0.56±0.39	0.56±0.39
Phosphate	mg L^{-1}	0.38±0.09	0.42±0.13	0.36±0.05	0.36±0.05
Nitrite	mg L^{-1}	0.55±0.61	0.03±0	0.01±0	0.01±0
Nitrate	mg L^{-1}	2.13±0.27	2.97±0.36	0.87±0.28	0.87±0.28
Ammonia	mg L^{-1}	0.01±0	0.01±0	0.01±0	0.01±0
pH	-	7.32±0.25	7.56±0.30	7.42±0.19	7.42±0.19

Table 1 also includes information on water chemistry characteristics such as COD, BOD, DO, iron, pH, nitrite, nitrate, ammonia, and phosphate. From February through May, COD values were 186.49, 21.84, 23.54, and 23.54 mg L^{-1}, respectively. According to cod observations, the waters in the minapadi region remain compatible with the national water quality standard class 3, which is equivalent to 40 mg L^{-1} (Government Regulation No. 22 2021). COD may serve as an indication of water contamination caused by household garbage. COD concentrations indicate the presence of organic matter, which may deplete the dissolved oxygen level of water when the value is too high, thus preventing aquatic species from meeting their oxygen requirement (Renitasari et al 2021). Between February and May, BOD levels were 2.98, 2.84, 2.42, and 2.42 mg L^{-1}, respectively. BOD measurements indicate that the waters in the minapadi region remain compatible with the national water quality standard class 3, equivalent to 6 mg L^{-1} (Government Regulation No. 22 2021). A high BOD value implies that the wastewater contains a substantial amount of biodegradable chemicals and a measurable amount of microbial contamination (Seroja et al 2018). BOD indirectly measures the amount of organic matter in water (Gupta et al 2017). In February, March, April, and May, the DO readings were 6.82, 6.82, 7.22, and 7.22 mg L^{-1}, respectively. If a water body's DO value is less than 5.0 mg L^{-1}, the water is unfit for human or even for animal consumption (Kumar et al 2019). Iron concentrations varied between 0.18 and 0.56 mg L^{-1}, with the greatest average levels occurring in April and May 2021, with an average of 0.56 mg L^{-1}, at five sampling sites. Iron observations indicate that the quantity of iron in the water is over the national water quality requirement for class 1, which is 0.3 mg L^{-1}, but is still acceptable for class 3 water quality standards (Government Regulation No. 22 2021). Fertilization may be responsible for this rise in iron value at the start of the minapadi process. Fertilization in agriculture is one of the factors contributing to the increase in iron values (Fischer et al 2018).

Additionally, Table 1 contains the nitrite, nitrate, and phosphate content. From February through May, the nitrite values in water were 0.55, 0.03, 0.01, and 0.01 mg L^{-1}, respectively. In February, nitrite levels surpassed the national water quality guideline limit of 0.06 mg L^{-1} (Government Regulation No. 22 2021). This may be caused by the decomposition of rice grains in the water, during the harvesting process. Plant degradation is one of the factors that contribute to elevated nitrite levels (Zhang et al 2020). The nitrate concentration is between 0.87 and 2.97 mg L^{-1}. Nitrosomonas and Nitrobacter produce nitrates during the nitrification process, which requires carbon and oxygen as energy sources (Odum & Barrett 2005). Tolerable nitrate content in water is 20 mg L^{-1} for grade 3 water quality requirements as specified in Republic of Indonesia Environmental Regulation (Government Regulation No. 22 2021). Between February and May, phosphorus levels at all sampling sites ranged between 0.36 and 0.42 mg L^{-1}. Phosphate measurements indicate that the waters in the minapadi region remain under the national water quality standard class 3, which is equivalent to 1 mg L^{-1} (Government Regulation No. 22 2021). While phosphate molecules cannot directly harm living organisms, an overabundance of phosphate may result in eutrophication and a rise in nitrate levels (Aye et al 2019). From February through May, the ammonia level was 0.01 mg L^{-1}. Ammonia measurements indicate that the waters in the minapadi region remain under the national water quality standard class 3, which is equivalent to 0.5 mg L^{-1} (Government Regulation No. 22 2021). The pH value is between 7.32 and 7.56, which is considered to be suitable for aquatic life (Sahidin et al 2018).

Community analysis of the plankton. Table 2 presents laboratory findings for plankton. According to laboratory findings, plankton of the phytoplankton type, but no zooplankton, was discovered in Samberembe. The phytoplankton present in the minapadi region is classified into five phyla and contains thirty species. Each observation in February is dominated by a different phylum, with the phylum Chlorophyta dominating, whereas March through May is dominated by the phylum Bacillariophyta. The diversity, evenness, saprobic and dominance indices are calculated from the processed data.

Table 2

The density of identified plankton (individuals L^{-1}) in the minapadi region

Filum	*Species*	*Density (individuals L^{-1})*			
		February	*March*	*April*	*May*
Bacillariophyta	*Cyclotella* sp	0	8	8	0
	Cymbella sp	0	20	8	13
	Diatoma sp	0	20	0	45
	Diploneis sp	0	0	5	0
	Eunotia sp	15	0	0	0
	Gyrosigma sp	0	33	33	15
	Navicula sp	65	395	460	490
	Nitzschia sp	0	45	15	245
	Pinnularia sp	0	38	65	63
	Placoneis sp	0	0	0	3
	Stauroneis sp	0	33	0	15
	Surirella sp	8	125	45	53
	Tabellaria sp	33	0	0	0
	Synedra sp	0	123	53	30
Charophyta	*Cosmarium* sp	0	0	0	3
	Zygnema sp	0	13	0	3
Chlorophyta	*Coelastrum* sp	0	13	3	3
	Closterium sp	155	0	0	3
	Golenkinia sp	0	23	0	0
	Microspora sp	8	0	0	20
	Pediastrum sp	0	0	0	8
	Scenedesmus sp	15	20	5	15
	Ulothrix sp	0	20	3	8
Cyanophyta	*Anabaena* sp	0	13	3	0
	Gomphosphaeria sp	0	58	33	3
	Oscillatoria sp	13	58	13	10
	Phormidium sp	0	90	5	0
	Spirulina sp	0	0	0	3
Euglenophyta	*Euglena* sp	35	0	3	8
	Phacus sp	8	8	5	0

Table 3 summarizes diversity, evenness, saprobic and dominance indices. From February through May, the diversity index was 1,03, 1,13, 1,33, and 1,40, respectively. This data indicates that diversity was at a modest level in February, when it reached a low point around the value of 1. Distributions were generally unequal, and the plankton community’s stability was generally poor. Due to the abundance of smaller species with low densities, the ecosystems become imbalanced (Lilisti et al 2021). In the detail of each sampling from February to May, SS1 saw monthly increases in value, while other sampling stations did not show a regular pattern.

Table 3

Diversity, evenness, dominance indices, saprobic quotient and saprobic index of plankton in minapadi area

Parameter	*February*	*March*	*April*	*May*
Diversity index (H')	1.03	1.13	1.33	1.40
Evenness index (E)	0.72	0.76	0.73	0.66
Dominance index (D)	0.45	0.35	0.37	0.35
Saprobic quotient (SQ)	0.74	1.00	0.98	0.99
Saprobic index (SI)	2.01	1.74	1.94	1.98

From February through May, the evenness index (E) was 0.72, 0.76, 0.73, and 0.66, respectively. This indicates that the community is unbalanced throughout the months of February, April, and May, owing to the low variety of plankton in the water. The plankton community is steady in March. Previous studies assert that this situation requires energy input to sustain ecological stability (Ray et al 2021). Each month, the homogeneity of plankton at the SS4 diminishes, whereas it varies at other sites. The dominance index (D) was 0.45, 0.35, 0.37, and 0.35 from February through May. This demonstrates a lack of dominance. The minapadi region does not have nor an abnormally high number of plankton species, neither a dominant species in the community (Lilisti et al 2021). As is the case with the evenness index (E), the dominance index value rises at the SS4, while it fluctuates monthly at the other stations. February had the lowest saprobic quotient, at 0.74. The value falls under the β-mesosaprobic category, which includes contaminants, both organic and inorganic, at values between 0.5 and 1 (Dresscher & Mark 1976). The saprobic index value for the sample falls within the range of 1.74 to 2.01, as indicated by the saprobic quotient results, which classify it as β-mesosaprobic. The pollution level in the minapadi area is classified as moderate (β-mesosaprobic) within the range of 1.5 to 2.5 (Persoone & De Pauw 1979; Zahradkova & Soldan 2008). By the end of May, all SI levels are relatively equal. Between February and March, the largest shift happened in the SS4. This result may be due to the proximity of SS4 to the residential area, which residents often use for social gatherings and dining, which may be why waste from these activities could enter the water. For the remainder of the sample stations, there have been few noticeable changes.

Discussion. The ecological quality of the minapadi region remains within the national standards of quality for the third-grade water, based on physical and chemical criteria. This study suggests that minapadi operations have little effect on the quality of the existing water bodies. The monthly water quality data showed that the region remains within an acceptable range for aquatic life, except in February when the nitrite level rose due to the harvesting process. Plankton was used to monitor the aquatic environment biologically, and it was found that February had the fewest plankton species due to elevated nitrite levels. The diversity in the minapadi region was at an intermediate level, because the species tend to be unequal and plankton communities tend to be unstable. The evenness index indicated that the community in the minapadi region was unstable in February, April, and May, mainly due to the heterogeneity of plankton living in low water. However, it was found to be stable in March. Additionally, the dominance index remained low month after month, suggesting that the minapadi region lacked of dominating plankton species. Overall, the water quality data based on SI values indicate that the minapadi region is included in the moderate monthly level of pollution. This study implies that while minapadi operations have little effect on the quality of the existing water bodies, there is still room for improvement in water quality.

Conclusions. After conducting a thorough investigation on the impact of minapadi operations in the local water bodies, it can be concluded that minapadi have a negligible effect on the quality of the water. A comprehensive analysis of various water quality parameters, including pH, nitrate, nitrite, ammonia, and total phosphate concentrations, found the water quality was compatible with the standards. Furthermore, no significant differences were observed in the water quality parameters between the areas impacted by the minapadi operations and the other areas. This study suggests that minapadi are not significantly contributing to the deterioration of the water quality in the water bodies. It should be noted, however, that the investigation was conducted under specific conditions and may not reflect the long-term effects of minapadi operations. Further research and monitoring are necessary to ensure the sustained protection and preservation of the local waters. Overall, based on the findings of this investigation, it can be concluded that minapadi operations have little to no effect on the state or quality of the local waters.

Conflict of interest. The authors declare no conflict of interest.

Acknowledgements. This work was supported by Ministry of Marine Affairs and Fisheries Republic of Indonesia, under the doctorate scholarship Number 26/SJ/KP.532/I/2019.

References

Ariska F. M., 2020 Prospect of development agribusiness creativity and innovation. Jurnal Peternakan 4(1):46–52.

Aye K. L., Itayama T., Kyaing, Shwe K. P., Tasaki K., Hayata Y., Tada A., 2019 Study on dynamic behaviors of water quality and mechanisms of eutrophication in Kandawgyi lake, Yangon City, Myanmar. Maejo International Journal of Energy and Environmental Communication 1(3):39–46.

Brraich O. S., Saini S. K., 2015 Water quality index of Ranjit Sagar wetland situated on the ravi river of indus river system. International Journal of Advanced Research 3(12):1498–1509.

Burdon F. J., Munz N. A., Reyes M., Focks A., Joss A., Räsänen K., Altermatt F., Eggen R. I. L., Stamm C., 2019 Agriculture versus wastewater pollution as drivers of macroinvertebrate community structure in streams. Science of The Total Environment 659:1256–1265.

Butler B. A., Ford R. G., 2018 Evaluating relationships between total dissolved solids (TDS) and total suspended solids (TSS) in a mining-influenced watershed. Mine Water and the Environment 37(1):18–30.

Cahyaningtyas I., Hutabarat P. S., 2013 [Plankton analysis study to determine the level of pollution in the estuary of the Semarang Baboon river]. Journal of Management of Aquatic Resources 2(3):74–84. [In Bahasa].

D’Souza A., Mishra A. K., 2018 Adoption and abandonment of partial conservation technologies in developing economies: the case of south asia. Land Use Policy 70(11):212–223.

Dresscher T. G. N., Mark H. v d., 1976 A simplified method for the biological assessment of the quality of fresh and slightly brackish water. Hydrobiologia 48:199–201.

Elshobary M. E., Essa D. I., Attiah A. M., Salem Z. E., Qi X., 2020 Algal community and pollution indicators for the assessment of water quality of Ismailia canal, Egypt. Stochastic Environmental Research and Risk Assessment 34(7):1089–1103.

Firth A. G., Baker B. H., Brooks J. P., Smith R., Iglay R. B., Davis J. B., 2020 Investigation of pathogenic bacterial transport by waterbirds: a case study of flooded and non-flooded rice systems in Mississippi. Water 12(6):1833.

Fischer P., Pöthig R., Gücker B., Venohr M., 2018 Phosphorus saturation and superficial fertilizer application as key parameters to assess the risk of diffuse phosphorus losses from agricultural soils in Brazil. Science of the Total Environment 630:1515–1527.

Freed S., Kura Y., Sean V., Mith S., Cohen P., Kim M., Thay S., Chhy S., 2020 Rice field fisheries: wild aquatic species diversity, food provision services and contribution to inland fisheries. Fisheries Research 229(5):105615.

Gupta N., Pandey P., Hussain J., 2017 Effect of physicochemical and biological parameters on the quality of river water of Narmada, Madhya Pradesh, India. Water Science 31(1):11–23.

Hariyati R., Putro S. P., 2019 Bioindicator for environmental water quality based on saprobic and diversity indices of planktonic microalgae: a study case at Rawapening lake, Semarang district, Central Java, Indonesia. Journal of Physics: Conference Series 1217(1):1–7.

Hidayah I., Januar H. I., Dwiyitno D., Prihantini N. B., 2021 Seasonal and spatial water pollution status at the rivers estuaries in Cirebon region. Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology 16(2):75–82.

Hidayat J. W., Hastuti R. B., Hadi M., Yulianto G., 2019 The structure of plankton as an environmental indicator for water management in upper part of Rawapening lake, Semarang Regency, Indonesia. Journal of Physics: Conference Series 1217(1):1–7.

Islam M. A., Jahan N., Quadir Q. F., Haque S. M., 2020 Assessment of fish pond sediments for growth, yield and nutritional quality of indian spinach (*Basella alba* L.). Archives of Agriculture and Environmental Science 5(1):33–39.

Kaur H., Shashi Warren A., Kamra K., 2021 Spatial variation in ciliate communities with respect to water quality in the Delhi NCR stretch of river Yamuna, India. European Journal of Protistology 79:125793.

Kibuye F. A., Gall H. E., Veith T. L., Elkin K. R., Elliott H. A., Harper J. P., Watson J. E., 2020 Influence of hydrologic and anthropogenic drivers on emerging organic contaminants in drinking water sources in the Susquehanna river basin. Chemosphere 245:125583.

Kovács A. D., Tóth G., Lóczy D., 2018 Water quality of the lower Drava river. Springer Geography F5:231–45.

Kumar R., Singh S., Sharma R. C., 2019 Application of WQI for assessment of water quality of high altitude lake Dodi Tal, Garhwal Himalaya, India. Sustainable Water Resources Management 5(3):1033–1042.

Lilisti, Zamdial, Hartono D., Brata B., Simarmata M., 2021 The structure and composition of macrozoobenthos community in varying water qualities in Kalibaru waters, Bengkulu, Indonesia. Biodiversitas 22(1):106–112.

Lu J., Li X., 2006 Review of rice–fish-farming systems in China — one of the globally important ingenious agricultural heritage systems (GIAHS). Aquaculture 260(1–4):106–13.

Magurran A. E., 1988 Ecological diversity and its measurement. Princeton University Press, New Jersey, 179 p.

Mahmudiyah E., Soedradjad R., 2018 [The effect of organic fertilizers and cultivation techniques on rice and fish production in the mina rice system]. Agritrop: Jurnal Ilmu-Ilmu Pertanian 16(1):17–37. [In Bahasa].

Nugroho H. B., Basuki F., Ariyati R. W., 2017 [The effect of different stocking densities on the growth rate of tilapia (*Oreochromis niloticus*, Linn. 1758) in the Minapadi cultivation system]. Journal of Aquaculture Management and Technology 6(2):21–30. [In Bahasa].

Odum E. P., Barrett G. W., 2005 Fundamentals of ecology. Thomson Brooks/Cole, Philadelphia, 624 p.

Paena M., Suhaimi R. A., Undu M. C., 2017 [Sedimentary characteristics of waters around intensive shrimp ponds during the rainy season in Punduh Bay, Pesawaran Regency, Lampung Province]. Jurnal Ilmu Dan Teknologi Kelautan Tropis 9(1):221–234. [In Bahasa].

Persoone G., De Pauw N., 1979 Systems of biological indicators for water quality assessment. ECSC, EEC, EAEC Luxembourg, pp. 39-75.

Ray J. G., Santhakumaran P., Kookal S., 2021 Phytoplankton communities of eutrophic freshwater bodies (Kerala, India) in relation to the physicochemical water quality parameters. Environment, Development and Sustainability 23(1):259–290.

Renitasari D. P., Kurniawan A., Kurniaji A., 2021 Blood glucose of tilapia fish oreochromis mossambica as a water bioindicator in the downstream of Brantas waters, East Java. AACL Bioflux 14(4):2040–2049.

Sahidin A., Zahidah, Herawati H., Wardiatno Y., Partasasmita R., 2018 Macrozoobenthos as bioindicator of ecological status in Tanjung Pasir Coastal, Tangerang district, Banten Province, Indonesia. Biodiversitas 19(3):1123–1129.

Seroja R., Effendi H., Hariyadi S., 2018 Tofu wastewater treatment using Vetiver grass (*Vetiveria zizanioides*) and Zeliac. Applied Water Science 8(1):1–6.

Singh R., Kashyap S., Pandey A., 2021 Climate impacts on water resources in india. in Climate impacts on water resources in india environment and health. In: Water science and technology library. Pandey A., Mishra S. K., Kansal M. L., Singh R. D., Singh V. P. (eds), pp. 331-369, Springer International Publishing, Cham.

Siregar Z. A., Anggoro S., Irianto H. E., Purnaweni H., 2020 Minapadi trend, need and sustainability in indonesia. E3S Web of Conferences 202:07028.

Syaukat Y., Julistia D. R., 2019 Analysis of income and factors determining the adoption of integrated rice-fish farming system in seyegan district, Sleman Regency, Yogyakarta, Indonesia. Journal of the International Society for Southeast Asian

Agricultural Sciences 25(1):66–79.

Tieri M., Ghelfi F., Vitale M., Vetrani C., Marventano S., Lafranconi A., Godos J., Titta L., Gambera A., Alonzo E., Sciacca S., Riccardi G., Buscemi S., Del Rio D., Ray S., Galvano F., Beck E., Grosso G., 2020 Whole grain consumption and human health: an umbrella review of observational studies. International Journal of Food Sciences and Nutrition 71(6):668–677.

Vaschetto P., Regaldo L., Polla W., Andrade V., Gervasio S., Gagneten A. M., 2021 Plankton community responses to anthropogenic pollution in an argentinian urban reserve. Water, Air, & Soil Pollution 232(10):427.

Wilhm J. L., Dorris T. C., 1968 Biological parameters for water quality criteria. BioScience 18(6):477–481.

Zahradkova S., Soldan T., 2008 Saprobic system. In: Encyclopedia of ecology. Jorgensen S. E., Fath B. D. (eds), pp. 3242–3343, Elsevier BV.

Zhang Z., Hu B., Chu C., 2020 Towards understanding the hierarchical nitrogen signalling network in plants. Current Opinion in Plant Biology 55:60–65.

*** Government Regulation No. 22, 2021 The Implementation of environmental protection and management. https://jdih.setkab.go.id/PUUdoc/176367/PP_Nomor_22_Tahun_2021.pdf

Received: 12 September 2023. Accepted: 15 January 2024. Published online: 04 February 2024.

Authors:
Zaenal Arifin Siregar, Research Center for Maritime and Land Bioindustry, National Research and Innovation Agency, Lombok, Indonesia, e-mail: zaienal1985@gmail.com
Hari Eko Irianto, Research Center for Maritime and Land Bioindustry, National Research and Innovation Agency, Lombok, Indonesia, e-mail: harieko_irianto@yahoo.com
Sutrisno Anggoro, Universitas Diponegoro, Faculty of Fisheries and Marine Science, Semarang, Indonesia, e-mail: sutrisnoanggoro52@gmail.com
Hartuti Purnaweni, Universitas Diponegoro, School of Doctoral Studies, Department of Environmental Science, Semarang, Indonesia, e-mail: hartutipurnaweni@gmail.com

This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

How to cite this article:
Siregar Z. A., Irianto H. E., Anggoro S., Purnaweni H., 2024 Monitoring of water quality with the plankton indicator and the saprobic index in a minapadi area. AACL Bioflux 17(1):156-165.