The water quality index and phytoplankton communities of Kokoh Putih River, Sembalun, East Lombok, Indonesia

[1]Fakhrurrozi, [1,2,3]Tri R. Soeprobowati, [1,3]Jumari Jumari

[1] Master Program of Biology, Faculty of Science and Mathematics, Diponegoro University, Semarang, Indonesia; [2] School of Postgraduate Studies, Diponegoro University, Semarang, Indonesia; [3] Center for Paleolimnology, Diponegoro University, Semarang, Indonesia. Corresponding author: T. R. Soeprobowati, trsoeprobowati@live.undip.ac.id

Abstract. Rivers are one of the surface-water sources that have a vital role in the aquatic ecosystems and living things in East Lombok. The Kokoh Putih River is one of the rivers whose water comes from Sagara Anak Lake of Mount Rinjani, East Lombok, Indonesia. This river supplies water mainly for bathing and washing, which affects the water quality. The study aimed to analyze the water quality and phytoplankton structure of the Kokoh Putih River. Water quality measurements were carried out at five sampling stations. The parameters measured and physically and chemically observed were pH, total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), total phosphate (P), nitrites, nitrates and ammonia (N), and turbidity. The results of the average value of each parameter were: pH=6.81, TDS=1.63 g mL^{-1}, TSS=175.3 g mL^{-1}, P=0.37 g mL^{-1}, nitrite=0.02 g mL^{-1}, nitrate<0.05 g mL^{-1}, DO=7.73 g mL^{-1}, N<0.1 g mL^{-1} and turbidity=179.5 g mL^{-1}. Based on the STORET method, the water quality of the Kokoh Putih River was the Class I, II and III ("highly polluted" category) and in the Class IV ("moderately polluted" category), while the results based on the water pollution index (PI) were in the "lightly polluted" category. The phytoplankton composition consists of 24 species belonging to 3 divisions. The Shanon-Wiener diversity index ranged from 2.52 to 2.78, the uniformity index ranged from 0.51 to 0.67 and the dominance index ranged from 0.08 to 0.11. The dominance of *Aulacoseira granulata* indicated meso-eutrophic waters, in line with the water phosphate measurement, ranging from 0.41 to 0.45 g mL^{-1}.

Key Words: phytoplankton structure, water quality, STORET, pollution index (PI).

Introduction. Freshwater ecosystems such as lakes, reservoirs, and rivers are natural resources that play an important role in ensuring water availability on land (Tyas et al 2021). The 2030 Agenda for Sustainable Development recognizes the importance of water quality and includes specific water quality targets in the Sustainable Development Goals (SDGs) (United Nations 2016). A safe supply of clean and fresh water is needed for all human beings. In developed countries, freshwater ecosystems supply water that is directly treated and distributed to consumers (Asnake et al 2021). Water quality control is a priority policy, in order to avoid the pollution's negative effects on human health. Potential sources of water pollution are industrial, domestic, geological, and agricultural (Helard et al 2021).

The Province of West Nusa Tenggara (NTB) has the potential for various natural resources, supplying agricultural, plantation and tourism activities. In addition, small large-scale industrial activities are also a mainstay for the local government in improving the community's economy. The growth and development of industrial and agricultural activities, as well as plantations, contribute to the decline in water quality. The Kokoh Putih River's upstream is located at the foot of Mount Rinjani and empties into the Elong-elong beach (BPSKLT 2022). Multivariate analysis help to determine the water quality states based on physical, chemical or biological composition (Banda & Kumarasamy 2020). Human activities around the Kokoh Putih River tend to increase. which affects the quality of river water and is closely related to river water flow, which is also influenced by the climatological factors in the dry and rainy seasons. Variations in water discharge due to seasons and various other conditions cause variations in the water quality parameters (Hu et al 2015). It is also caused by the decomposition of organic matter in the river by microorganisms (Soeprobowati et al 2016).

River ionic chemistry can provide important information about processes that affect river water levels, for example, the atmospheric precipitation, evaporation crystallization, and the amount of natural material carried by the river water bodies (Qu et al 2018). A river is also a network of water flows from upstream springs (Government Regulation no. 35 of 1991). The Kokoh Putih River is used for many competing applications such as sources of drinking water and of irrigation for agriculture. The characteristics of the river's upstream are: a shallow and narrow river bodies, a high, rocky, and clear water, and a fast flow, heavily loaded. River flow accumulation occurred in the downstream area and the ecosystem could not cope with the high pollution load (Saraswati et al 2019).

The presence of phytoplankton is related to the surrounding aquatic environment (Munthe et al 2012). Phytoplankton has an important role in the river ecosystem because it responds to changes (Soeprobowati et al 2021) and it has a substantial contribution to the primary production in aquatic ecosystems (Zwart et al 2015), maintaining a network of trophic interactions with consequences that determine the ecosystem functions (Abonyi et al 2018). Phytoplanktons, like terrestrial plants, require nutrients such as nitrate, phosphate, silicate and calcium at various levels, depending on the species. Some phytoplanktons can fix nitrogen and can grow in areas where nitrate concentrations are low (Kumar et al 2020). This study aimed to analyze the water quality indicators of the Kokoh Putih River Lombok Island, Sembalun district, based on physicochemical parameters and phytoplankton community.

Material and Method

Study area. The research was conducted in Kokoh Putih River, Belok Tepung Village, Sembalun District, East Lombok, Indonesia, in October 2020. A purposive random sampling was conducted at 5 sampling stations with different characteristics, representing every activity around the waters of the Kokoh Putih River such as: agriculture, plantations, forest, and residential areas (Table 1). The research stations were located on the river flow, from the Lake Segara Anak Mount Rinjani, in the upstream, to the downstream, at the estuary of the Elong-Elong coast (Figure 1). The sampling locations' different characteristics are visible in Figures 2-6.

Table 1

Geographical position and description of the research stations

Stations	*Geographical position*	*Stations description*
S1	8°17´34.61´´ S and 116°28´10.67´´ E	The upstream area is a forest area
S2	8°16´3.33´´ S and 116°28´10.67´´ E	Plantation areas and tourist areas
S3	8°15´40.73´´ S and 116°28´42.22´´ E	Under the bridge, rocks
S4	8°15´37.34´´ S and 116°28´45.49´´ E	Rocky, forest area
S5	8°17´33.32´´ S and 116°28´50.15´´ E	Forest

Water sample collection and analysis. The collection of water samples was carried out at five research stations following the Indonesian National Standard (SNI 6989.57-2008). Water samples were collected in 1 L clean plastic bottles, labeled, and placed into a cooler. Physicochemical parameters such as temperature, pH and dissolved oxygen (DO) were measured directly (in-situ) in the field. Other parameters were analyzed at the Dinas Lingkungan Hidup Kehutanan Laboratory (Laboratory of Environmental and Forestry Office of Mataram, Nusa Tenggara Barat-NTB, Indonesia). The results of the physical and chemical parameters were compared with the criteria of the water quality standards in Government Regulation Number 22 of 2021, concerning the implementation of environmental protection and management. The determination of the water quality status of the Kokoh Putih River used the methods STORET (Storage and Retrieval) and the Pollution Index (PI).

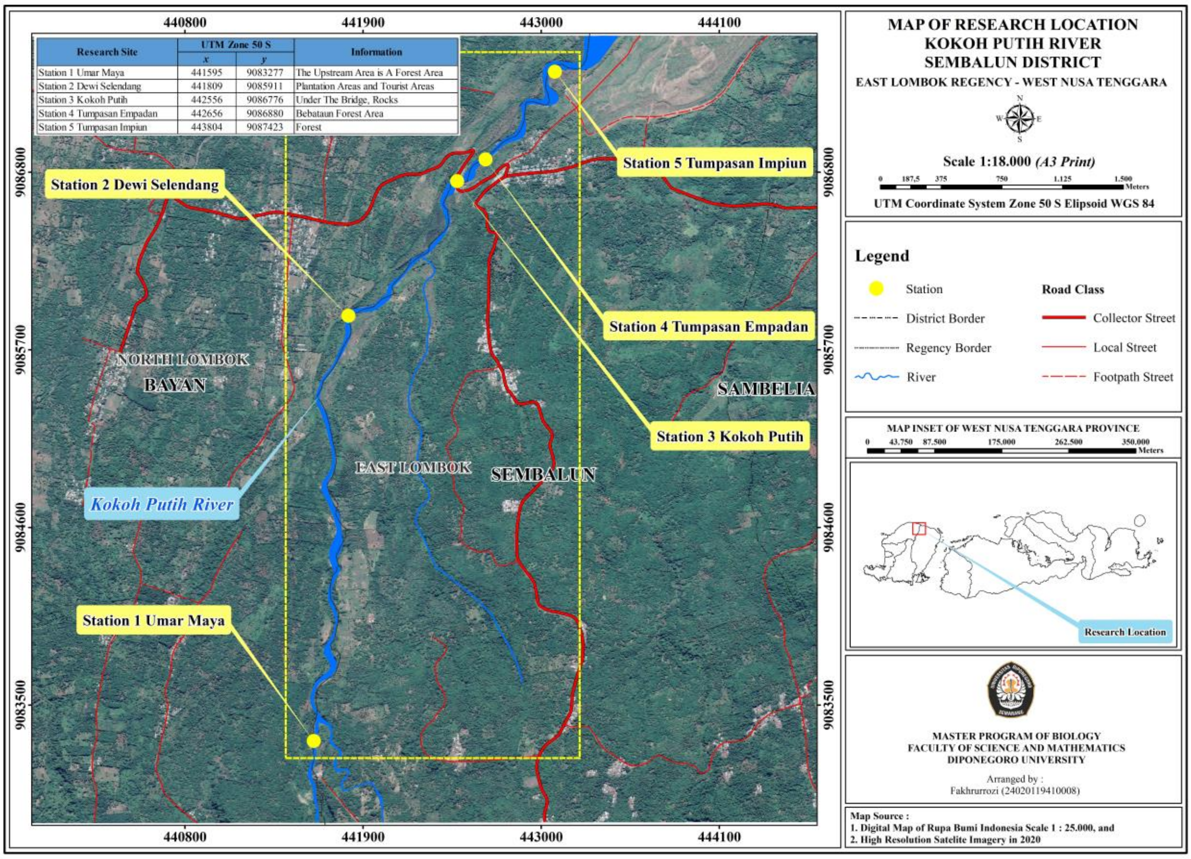

Figure 1. The sampling station at Kokoh Putih River.

Figure 2. Station 1 (S1): the outflow from Segara Anakan Lake (original photo).

Figure 3. Station 2 (S2): at the waterfalls of Kokoh Putih River, Sembalun (original photo).

Figure 4. Station 3 (S3): at a rocky riffle, in a Kokoh Putih River meander. Sembalun, East Lombok (original photo).

Figure 5. Station 4 (S4): the rocky area of Kokoh Putih River, Sembalun, East Lombok (original photo).

Figure 6. Station 5 (S5): the forest area of Kokoh Putih River, Sembalun, East Lombok (original photo).

Phytoplankton sampling. Phytoplankton samples were taken at the five stations, using a plankton net with a size of 20 m. 30 L of water were filtered, then the sample was accommodated in a bottle and preserved (4% formaldehyde solution).

Data analysis

STORET index. The Storage and Retrieval of Water Quality Data System (STORET) method is one of the techniques often used in Indonesia to determine the water quality status based on the US-EPA (United States Environmental Protection Agency) value system. The STORET index was calculated following the procedure described in the decree of the Indonesian Ministry of Environmental Number 115 year 2003. In this research 10 physical, chemical, and biological water quality parameters were compared to the water quality standard value and then were scored by -1 for physical, -2 for chemical, and -3 for biological parameters, respectively. If the measurement results meet the water quality standards (measurement results<quality standards), a score of 0 is given. If the measurement results do not meet the water quality standards (measurement results>quality standards), a score is given as in Table 2 (Rahim &

Soeprobowati 2019). The negative sum of all the parameters is calculated and the quality status of the total score is obtained using the defined score system (Table 3). The water quality index was interpreted based on the criteria in Table 3 (Rintaka et al 2019).

Table 2
Assessment of water quality parameters (Environment Minister of Indonesia Decree No. 115/2003)

Number of parameters	*Value*	*Parameter*		
		Physical	*Chemical*	*Biologycal*
< 10	Maximum	-1	-2	-3
	Minimum	-1	-2	-3
	Average	-3	-6	-9
≥ 10	Maximum	-2	-4	-6
	Minimum	-2	-4	-6
	Average	-6	-12	-18

Table 3
Water quality classification according to the US-EPA value system

Score	*Class*	*Characteristics of water quality*
0	A	Meet the quality standard
-1 to -10	B	Slightly polluted
-11 to -30	C	Moderately polluted
≥-31	D	Highly polluted

Determination of water class. Determination of water class is carried out by comparing the concentration of all water quality parameters listed in Government Regulation Number 22 of 2021, compared with the water quality standards for Class I, Class II, Class III, and Class IV for each of these parameters:
1. Class I, water intended for drinking water, raw water, and/or other uses requiring the same quality.
2. Class II, water intended for recreation infrastructure/facilities, fish farming, animal husbandry, irrigating crops, and/or other uses requiring the same quality.
3. Class III, water intended for the cultivation of freshwater fish, animal husbandry, water for irrigating crops, and/or other uses requiring the samequality.
4. Class IV, water intended to irrigate crops and or other uses that require the samequality.

Pollution index (PI). The Pollution Index (PI) is based on the values of four predetermined water quality parameters, namely TSS, DO, pH and BOD. The Pollution Index (PI) is calculated as follows (Environment Minister of Indonesia Decree No. 115/2003):

$$PI_j = \sqrt{\frac{(C_i / L_{ij})^2_M + (C_i / L_{ij})^2_R}{2}}$$

Where:
PI_j - pollution index for j used;
C_i - concentration of measured water quality parameter i;
L_{ij} - concentration of water quality parameter i in the water quality standard for j used;
M - maximum;
R - average.

The evaluation of the PI value is as follows (Table 4):

Table 4

Water quality status criteria based on the PI method

Value range	*Water quality status*
$0 \le PIj \le 1.0$	Meet quality standards
$1.0 < PIj \le 5.0$	Lightly polluted
$5.0 < PIj \le 10$	Moderately polluted
$PIj > 10$	Heavily polluted

Identification and calculation of phytoplankton community structure. The identification of phytoplankton was carried out in the laboratory by observation under a microscope and using the phytoplankton identification books of Vuuren et al (2006), Bellinger & Sigee (2011), Guiry & Guiry (2022). The abundance of phytoplankton is expressed in individuals per liter and it is calculated as follows (APHA 2012):

$$N = \frac{T}{L}\, x \frac{P}{p} x \frac{V}{v} x \frac{1}{W}$$

Where:
N - number of phytoplankton organisms per liter;
T - area of the cover glass (mm^2);
L - field of view (mm^3);
P – total number of phytoplankton organisms;
p - number of observed organisms in the field of view;
V - volume of filtered phytoplankton samples (mL);
v - volume of phytoplankton sample under the cover glass (mL);
W - volume of filtered phytoplankton samples (lt).

The index used to determine the level of species diversity in a community is using the Shanon Wiener index (Magurran 2004):

$$H = \sum_{i=1}^{n} Pi\ In\ Pi$$

Where:
H - index of species diversity;
Pi - probability function for each part as a whole (ni/N);
ni - number of individuals of type-i;
N - total number of individuals.

The calculation of the uniformity index is based on the equation of Magurran (2004):

$$E = H'/H_{maks}$$

Where:
e - uniformity index;
H' - diversity index;
Hmax - ln S;
S - number of types.

The dominance index is used to determine the extent to which a species dominates another group. The dominance index was obtained using the Simpson index (Magurran 2004):

$$D = \sum_{i=1}^{s} \left(\frac{ni}{N}\right) 2$$

Where:
D - Simpson dominance index;
ni - number of individuals of type i;
N - total number of individuals;
S - number of types (species).

Results and Discussion

Temperature (^{0}C). The water temperature in the Kokoh Putih River ranged from 30.4 to 34.8°C, as in Figure 7, while the average temperature value was 33.7°C. Even though all five research stations had different geo-climatic situations, the water temperature at each location was almost the same. The average water temperature of the Kokoh Putih River is still above the water quality based on classes I, II, III and IV. The existence of a supportive environment due to factors such as temperature and airflow greatly affects water quality parameters (Kim et al 2020). According to Muhaemi et al (2015), the temperature of water bodies is influenced by several factors such as season, latitude, height above sea level (asl), time, air circulation, water flow, tides, and water depth. The water temperature fluctuates with the season (Romanescu et al 2016).

Dissolved oxygen (DO). The dissolved oxygen (DO) Kokoh Putih River ranged from 7.58 to 7.85 g mL^{-1} and had a mean value of 7.73 g mL^{-1}, as in Figure 7. The average DO value in the Kokoh Putih River has exceeded the quality standards for Class I, II, and III, according to Government Regulation No. 22/2021. In general, the water quality parameters have a strong interdependence, the amount of DO depending on the water temperature and on the partial pressure of the surface water. The main parameter is temperature because it affects the ability of the water to absorb oxygen. The oxygen generated by photosynthesis in the aquatic ecosystems determines the oxygen saturation (Boyd 2015).

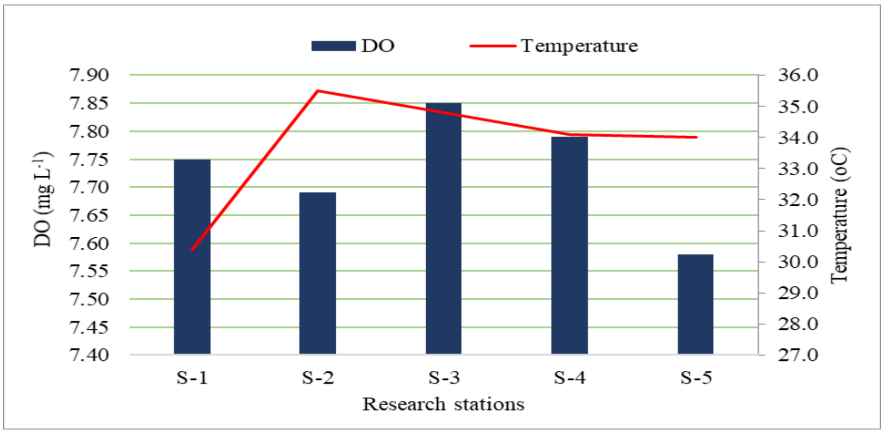

Figure 7. DO and temperature at each station of the Kokoh Putih River.

Total dissolved solid (TDS). The results of the TDS value at all sampling stations on the Kokoh Putih River ranged from 1,610 to 1,700 g mL^{-1} and an average value of 1,638 g mL^{-1}, as in Figure 8. The average TDS value for the Kokoh Putih river exceeded the water quality standard threshold for all classes and at all stations, based on Government Regulation Number 22 of 2021. The Total Dissolved Solids (TDS) indicator refers to the compounds of inorganic ions in water, that originated from domestic waste, industrial waste (detergents), or natural water (chlorides, bicarbonates, flour, sulfates, and other ions) (Hadi et al 2019). In the relatively undisturbed environment of the Tibetan Plateau, the water chemistry of the rivers was found to be heavily influenced by the composition of the bedrock in the catchment (Qu 2018).

Total suspended solids (TSS). The TSS in the Kokoh Putih River, ranged from 141.5 to 188.0 g mL^{-1}, as in Figure 8, and had an average value of 175.3 g mL^{-1}. The TSS value of the Kokoh Putih River exceeded the water quality for classes I and II, based on Government Regulation Number 22 of 2021, but not for classes III and IV. The monitored waters of the Kokoh Putih River had turbidity ranging from low to high. An increasing water flow rate has a negative effect on the TSS concentrations, causing higher water turbidity (Tuttle-Raycraft 2019). According to Yulius et al (2018), the composition of suspended solids in waters has a positive correlation with turbidity. TSS consists of silt and fine sand and microorganisms, mainly caused by soil erosion by the increasing water flow rate. The TSS indicator refers mainly to inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates) and small amounts of organic matter that are dissolved in water (Ustaoğlu et al 2020).

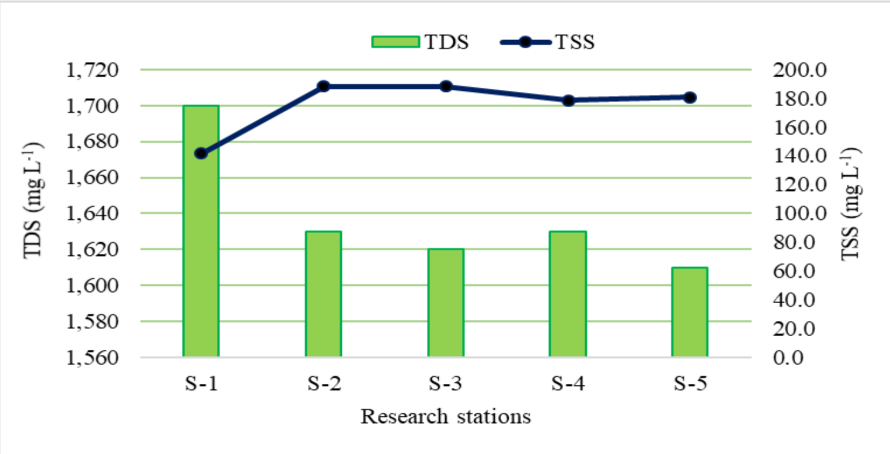

Figure 8. TDS and TSS at each station of the Kokoh Putih River.

Turbidity. The turbidity ranged from 11.1 to 64.2 g mL^{-1}, with an average of 35.9 g mL^{-1}, which exceeded the water quality standard for all classes, as in Figure 9.

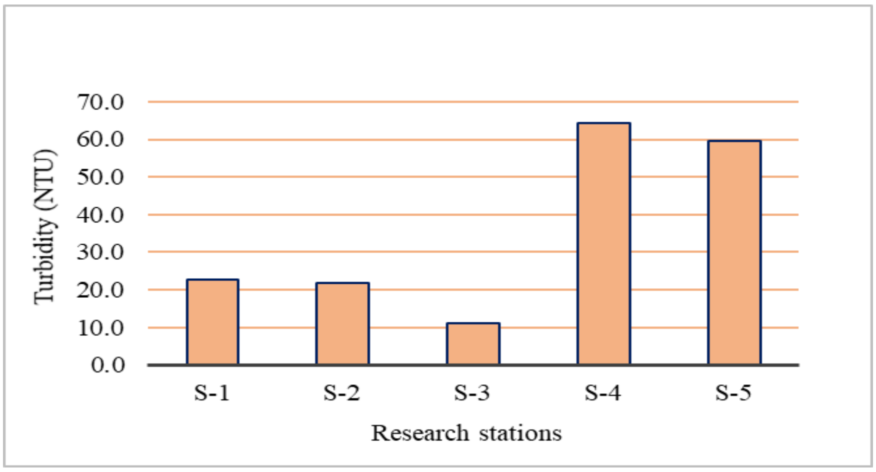

Figure 9. Tubidity at each station of the Kokoh Putih River.

The highest level of turbidity was recorded at station 4, with a value of 64.2 mg L^{-1}, due to the impacts from the local community around the river flow, essentially related to agricultural and plantation activities, so that the land in this area is prone to erosion. Erosion can be influenced by climatic factors such as rainfall, soil type, soil slope, and human activities. Land management around the rivers can affect erosion which in turn will affect water quality (Neupane et al 2015). High rainfall is also one of the factors causing high levels of turbidity in the waters (Lee et al 2016). High rainfall causes high surface runoffs and erosion. The brightness level is due to the sunlight intensity penetrating the waters, is strongly inhibited by the turbidity.

The degree of acidity (pH). The pH was in the range of 6.4 to 7.4, as in Figure 10, with an average value of 6.81. Based on Government Regulation Number 22 of 2021, it was still below the threshold for the quality standard water for all classes, ranging from 6 to 9. The degree of acidity (pH) of the water indicates the presence of hydrogen ions in the Kokoh Putih river water, which is acidic. Acidification of the water can be influenced by water temperature through the distribution of agricultural and other human activities around the rivers. It is also influenced by the properties of the soil and sediment particles, and also by environmental factors (Wu et al 2020). According to Qu et al (2018), an increase in fertilizer accumulation in the sediment is related to its size.

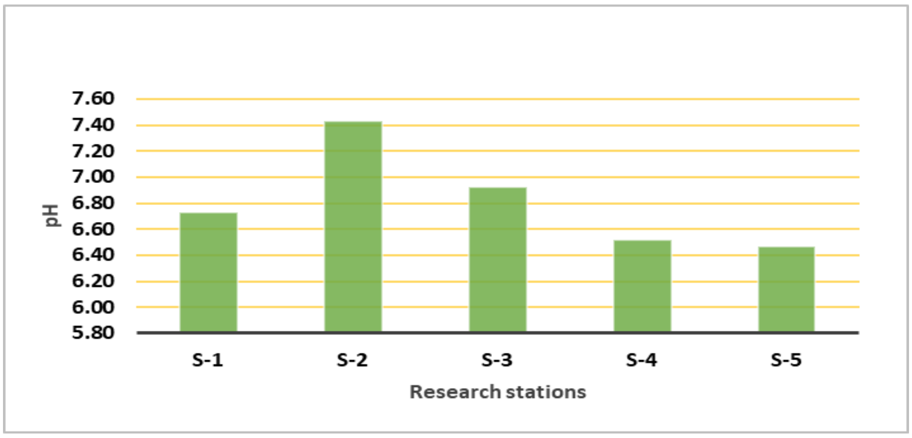

Figure 10. The pH at each station of the Kokoh Putih River.

Nitrate (N). Nitrate in the Kokoh Putih River was <0.05 g mL^{-1} (Figure 11). The concentration of nitrate in the Kokoh Putih River is still below the water quality standard threshold for all classes. A low concentration of nitrate values in the Kokoh Putih River does not affect the human and agricultural uses of water or the river sediment. A high concentration of nitrate is determined by the sediment's transport. In sediments, nitrate is produced from the biodegradation of organic materials into ammonia, which is then oxidized to nitrate (Patty 2014). The amount of nitrate is usually greater than the amount of nitrite because nitrite is unstable in the presence of oxygen, being a transient form between ammonia and nitrate. Nitrate is an unwanted ion in water because it has detrimental effects on human health (Ewaid & Abed 2017).

Nitrite (N). The nitrite (NO_3-N) analysis from all sampling stations of the Kokoh Putih River ranged from 0.02 to 0.03 g mL^{-1}, with an average value of 0.028 g mL^{-1}, as in Figure 11. The nitrite concentration in the Kokoh Putih River is still below the threshold of the Government Regulation 22 of 2021 on the water quality standards, for all classes. The river water quality can decline due to changes in land cover patterns around the watershed, following increased human activity. Land-use change is considered to be the main influencing factor behind changes in hydrological systems that lead to changes in the water quality (Zhang et al 2016). A comprehensive assessment of this effect will require a systematic collection of seasonal data on the nitrite exchanges along the watershed (Akbarzadeh et al 2018).

Phosphate. The phosphate in the Kokoh Putih River ranged from 0.41 to 0.45 g mL^{-1}, with an average of 0.37 g mL^{-1}, as in Figure 12. The average value of the phosphate in the waters of the Kokoh Putih river has exceeded the water quality standard threshold for classes I and II, based on the Government Regulation No. 22 of 2021, but was still below the threshold for classes III and IV. Phosphate in waters can be in the form of orthophosphate (PO_4^{3-}). Thus, high levels of phosphate are determined by agricultural runoff and household waste (Fashae et al 2019), such as fertilizers and detergent residues (Kundu et al 2015).

Ammonia (N). The ammonia analysis results for the Kokoh Putih River from all sampling stations were <0.1 g mL^{-1} (Figure 12). The ammonia in the waters occurs mainly due to the excretions of aquatic organisms. The impact of ammonia emissions on the nitrate formation shows spatial variations and seasonal changes which are also related to the meteorological conditions and environmental chemistry. Relatively low temperatures and a high relative humidity can cause ammonia concentrations to increase (Yin et al 2018). Another cause is too high mud contents in the river flow. The increase in ammonia in rivers is also influenced by increases in temperature, dissolved oxygen and pH (Erisman 2021).

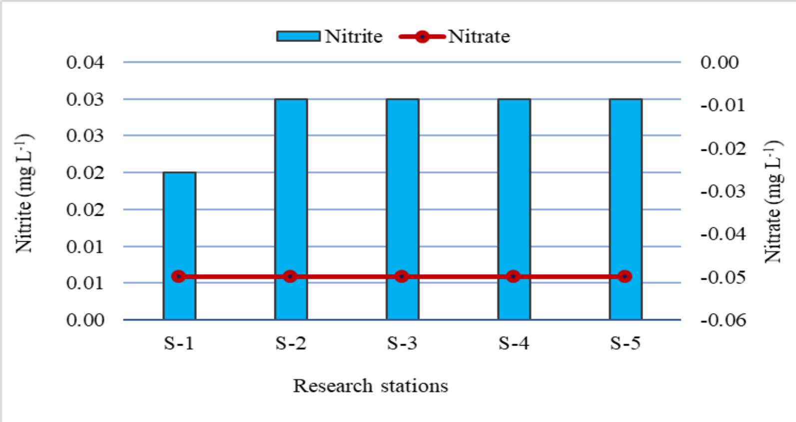

Figure 11. The nitrate and nitrite at each station of the Kokoh Putih River.

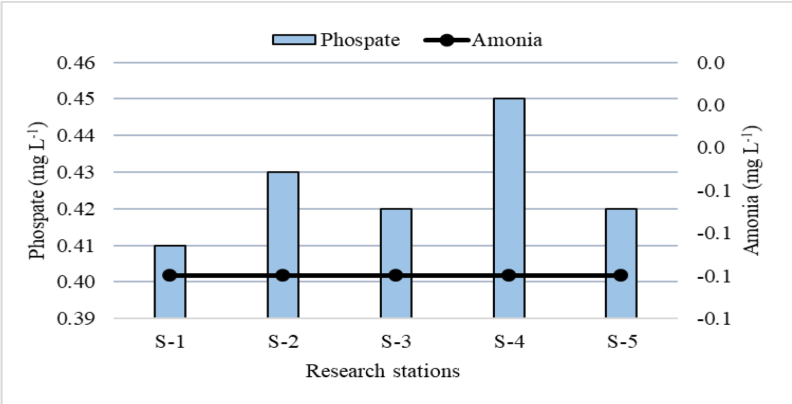

Figure 12. The phosphate and ammonia at each station of the Kokoh Putih River.

Water quality status. Measuring the water quality of the Kokoh Putih River used the STORET method, which describes the parameter values related to the quality standards. An assessment of the Kokoh Putih River's water quality status, based on the US-EPA system can be seen in Table 5. Based on the US-EPA system, the use classes were assigned EPA water quality status categories, as follows: Class I, used as a source of raw drinking water, with a score of -78 was in category D, highly polluted. Class II, used for fisheries, recreation, livestock, and aquaculture, with a score of -78, was in category D, highly polluted. Class III, for aquaculture, fisheries, and agriculture activities, with a score of -48, was in category D, highly polluted. Class IV, for agricultural activities, with a score of -30, was included in category C, moderate pollution. In general, water quality is influenced by an increase in the water flow from upstream to downstream and by human activities. Water needs for various human activities vary. According to Putri et al (2019), industrial areas, agricultural land, and residential areas are the main contributors to ammonia. High ammonia concentrations in water can reduce dissolved oxygen levels, which affect physiological and metabolic functions, such as respiration (Zhang et al 2017).

Table 5

Status of Kokoh Putih River water quality using the STORET method

Parameters	*Unit*	*Min*	*Max*	*Avg.*	*Score Class I*	*Score Class II*	*Score Class III*	*Score Class IV*
				Physical				
Temperature	ºC	30.4	35.5	33.76	-8	-8	-8	0
TDS	g mL^{-1}	1610	1700	1638	-10	-10	-10	0
TSS	g mL^{-1}	141.5	188.0	175.3	-10	-10	0	0
Turbidity	g mL^{-1}	11.1	64.2	35.9	-10	-10	-10	-10
				Inorganic chemical				
pH	–	6.47	7.43	6.81	0	0	0	0
DO	g mL^{-1}	7.58	7.85	7.73	-20	-20	-20	-20
Nitrate	g mL^{-1}	<0.05	<0.05	<0.05	0	0	0	0
Nitrite	g mL^{-1}	0.02	0.03	0.028	0	0	0	0
Phosphate	g mL^{-1}	0.41	0.45	0.37	-20	-20	0	0
Ammonia	g mL^{-1}	<0.1	<0.1	<0.1	0	0	0	0
Pollution index					-78	-78	-48	-30

The results of the water quality parameters were calculated using the PI method and the water quality parameters test values were used to determine the state of the waters in the Kokoh Putih River, for each segment. Based on the parameters to be tested are temperature, TDS, TSS, turbidity, pH, DO, nitrate, nitrite, phosphate, and ammonia parameters. Based on the calculation of water quality using the IP method, the status value of the Kokoh Putih River is 1 to 5 with a score of 2.40-2.85 in Table 6, so the Kokoh Putih River is classified as lightly polluted. Residual feed and fertilizers were released into the environment, increasing phosphate and other organic matter into rivers. High organic matter can double the primary productivity of waters and ultimately reduce dissolved oxygen (Bosman et al 2021).

The results showed that the pollution state determined by STORET and PI indices was different. If compared to the water quality standard on Government Regulation Number 22 in the year 2021, the parameter that exceeded thresholds for all classes was turbidity, and for Classes I and II were TSS. The standard value for USA and Indonesia was different, therefore the result of the STORET index is usually higher state compared to the IP index. This was also found in Lampung Bay (Barokah et al 2017), Pengilon Lake Central Java (Soeprobowati et al 2021).

Table 6

Water quality status at Kokoh Putih River station using the pollution index method

Station	*Pollution index value (PI)*	*Pollution criteria*
S-1	2.40	Lightly polluted
S-2	2.83	Lightly polluted
S-3	2.85	Lightly polluted
S-4	2.79	Lightly polluted
S-5	2.82	Lightly polluted

Phytoplankton community structure. Phytoplankton showed significant variations in the community structure. In Kokoh Putih River there were 24 species that belong to the division Chlorophyta (9 species), Bacillariophyta (12 species), and Cyanobacteria (3 species), as in Figure 13. Bacillariophyta represents a higher number of taxa encountered during the study. The dominance of the Cyanophyta division can be indicated through the visualization of dark green water (Agung et al 2017).

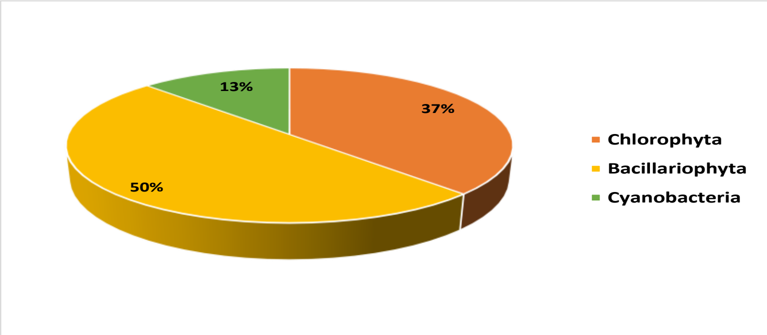

Figure 13. Phytoplankton population of the Kokoh Putih River.

Phytoplankton species that can be found in all stations are *Microspora* sp., *Staurastrum* sp., *Pediastrum tetras*, *Bacteriastrum* sp., *Synedra ulna*, *Navicula platystoma*, *Navicula* sp., *Oscilatoria limosa*, *Aulacoseira granulata*. The presence of *A. granulata* indicates hypereutrophic water conditions (Soeprobowati et al 2012,2018). In addition, in the Chlorophyta division, there is a species of *Spyrogira* sp., indicating a eutrophic status of the water bodies (Dhakal et al 2021). *S. ulna* is a species that is tolerant of high organic matter content and is often found in limnic and lotic ecosystems (Suhry et al 2020).

The Shannon-Wiener diversity index shows that the waters of the Kokoh Putih River have the following diversity index, by station: S-1 of 2.78, S-2 of 2.75, S-3 of 2.61, S-4 of 2.52 and S-5 of 2.65, as in Figure 14. With a diversity index value of H'<3, the waters of the Kokoh Putih River have a diversity in the medium range. S-4 is the most unstable location, with a phytoplankton diversity of 2.52 and with the lowest even distribution index, of 0.51. The results of the analysis showed that the nutrient that had a significant effect on the number of phytoplankton observations was phosphate. The Chlorophyta division of phytoplankton is estimated to be strongly influenced by changes in nutrient availability. Based on the results of the analysis of the stations, the uniformity index value (E) of the Kokoh Putih River is in the range between 0.5–0.6 in Figure 15. The maximum value of the uniformity index is 1, indicating a uniform distribution. Thus, the Kokoh Putih River has a medium uniformity. The highest uniformity value is found at station 1, which is 0.6, and the lowest is 0.5, at S-4. The lower the uniformity index value, the smaller the population uniformity, suggesting that certain species are dominant over other species, in the population.

Based on the results presented in Figure 16, the highest phytoplankton dominance index value was observed at S-4 (0.11) and the lowest at S-1 (0.08). A dominance index value whose value is in the range 0-1, as for the Kokoh Putih River, is included in the moderate dominance criteria. Certain types of aquatic biota are dominant in the waters, due to the influence of environmental pressure: a dominant species can adapt to a stressful environment. The greater the value of the dominance index, the greater the population of a particular species. The difference in the total number of species abundance between stations one to station five can be influenced by the presence of physiological processes. External factors that influence it are predation, turbulence, changes in salinity and turbidity (Afifah et al 2021).

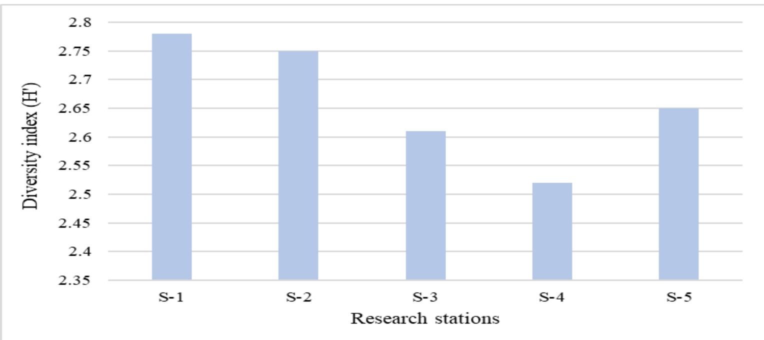

Figure 14. Phytoplankton diversity index in the Kokoh Putih River.

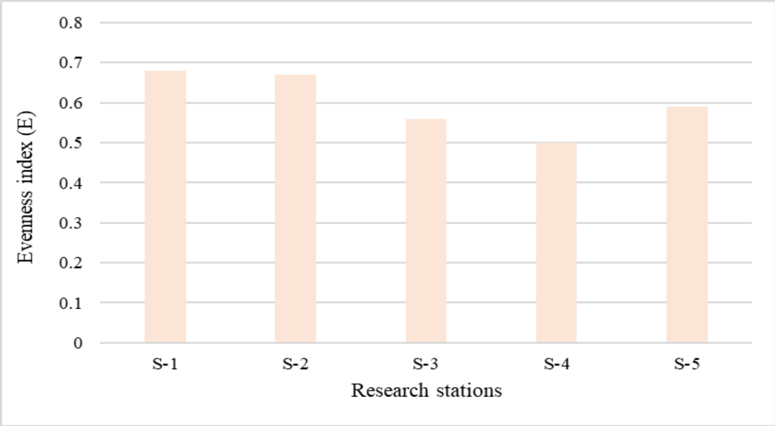

Figure 15. Phytoplankton evenness in the Kokoh Putih River.

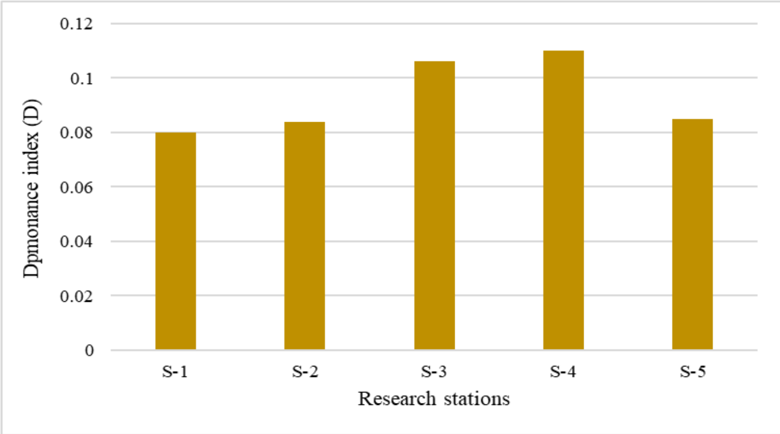

Figure 16. Phytoplankton dominant in the Kokoh Putih River.

Conclusions. Based on the STORET method, the water quality of the Kokoh Putih River for classes I, II, and III are in the category of highly polluted, while for class IV it is classified as moderately polluted. Based on the PI index, the Kokoh Putih River is lightly polluted. Parameters that exceed the water quality standards are turbidity for all classes, phosphate, and TSS for Classes I and II. Overall, the phytoplankton community at Kokoh Putih River is dominated by Bacillariophyta. A localized dominance of *A. granulata* indicated meso-eutrophic waters, in line with the phosphate values (from 0.41 to 0.45 g mL^{-1}, with an average of 0.37 g mL^{-1}).

Acknowledgements. The authors would like to thank the Directorate of Research and Community Service, Deputy for Research Strengthening and Development of the Ministry of Research and Technology for providing doctoral research grants under the Research Program Implementation Agreement Number: 1/E1/KP.PTNBH/2021. The authors would also like to express gratitude to the Research Institute for Fish Breeding (RFIB) Sukamandi, Subang, West Java, Indonesia, for allowing the use of its facilities in order to conduct the experiment. The authors thank the staff members of RFIB: Adam, Nurfansuri, Hariono, Lamanto and Uus for their participation and assistance during the research.

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

References

Abonyi A., Horváth Z., Ptacnik R., 2018 Functional richness outperforms taxonomic richness in predicting ecosystem functioning in natural phytoplankton communities. Freshwater Biology 63(2):178-186.

Afifah J., Hariyati R., Soeprobowati T. R., 2021 Epilithic diatoms diversity in the reservoir of Universitas Diponegoro, Semarang. Indonesian Journal of Limnology 2(1):65-75.
Agung B., Piranti, A., Carmudi C., 2017 Relationship between water quality and abundance of Cyanophyta in Penjalin Reservoir. UNEJ E-Proceeding, pp. 52-56.
Akbarzadeh Z., Laverman A. M., Rezanezhad F., Raimonet M., Viollier E., Shafei B., Cappellen P., 2018 Benthic nitrite exchanges in the Seine River (France): An early diagenetic modeling analysis. Science of the Total Environment 628–629:580-593.
Asnake K., Worku H., Argaw M., 2021 Integrating river restoration goals with urban planning practices: the case of Kebena river, Addis Ababa. Heliyon 7:e07446.
Banda T. D., Kumarasamy M. V., 2020 Development of water quality indices (WQIs): A review. Polish Journal of Environmental Studies 29(3):2011-2021.
Barokah G. R., Ariyani f., Siregar T. H., 2017 Comparison of STORET and pollution index method to assess the environmental pollution status: a case study from Lampung Bay, Indonesia. Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology 12(2):67-74.
Bellinger E. G., Sigee D. C., 2011 Freshwater algae: identification and use as bioindicators. John Wiley & Sons, 284 p.
Bosman O., Soesilo T. E. B., Rahardjo S., 2021 Pollution index and economic value of vannamei shrimp (*Litopenaeus vannamei*) farming in Indonesia. Indonesian Aquaculture Journal 16(1):51-60.
Boyd C. E., 2015 Water quality: An introduction. Springer Cham, Berlin, 357 p.
Dhakal S., Rai S. K. Pathak M. L., 2021 Enumeration of freshwater algae in Godawari area, Lalitpur district, central Nepal. Banko Janakari 31(1):41–50.
Erisman J. W., 2021 How ammonia feeds and pollutes the world. Science 374(6568):685-686.
Ewaid S. H., Abed S. A., 2017 Water quality index for Al-Gharraf River, Southern Iraq. Egyptian Journal of Aquatic Research 43(2):117-122.
Fashae A. O, Ayorinde H. A., Olusola, A. O., Obateru R. O., 2019 Land use and surface water quality in an emerging urban city. Applied Water Science 9:25.
Guiry M. D., Guiry G. M., 2022 Algae base. World-wide electronic publication. National University of Ireland, Galway. https://www.algaebase.org.
Hadi M. P., Fadlillah L. N., Tifani A. R. S., Ramdan V. K., 2019 Heavy metal pollution and water quality assessment in Belik River Yogyakarta. IOP Conference Series: Earth and Environmental Science 256:012014.
Helard D., Indah S., Wilandari M., 2021 Spatial variation of electrical conductivity, total suspended solids, and total dissolved solids in the Batang Arau River, West Sumatera, Indonesia. IOP Conference Series: Materials Science and Engineering 1041:012027.
Hu Q. Y., Li M., Wang C., Ji M., 2015 Influence of powdered activated carbon addition on water quality, sludge properties, and microbial characteristics in the biological treatment of commingled industrial wastewater. Journal of Hazardous Materials 295:1-8.
Kim J., Jeong H., Kim H., Kim Y., Yang D., 2020 A non-parametric trend analysis of water quality using water environment network data in Nakdong River. Journal of Environmental Impact Assessment 29(1):61–77.
Kumar R., Kumari R., Prasad C., Tiwari V., Singh N., Mohapatra S., Merugu R., Namtak S., Deep A., 2020 Phytoplankton diversity in relation to physicochemical attributes and water quality of Mandakini River, Garhwal Himalaya. Environmental Monitoring Assessment 192(12):799.
Kundu S., Coumar M. V., Rajendiran S., Rao A., Rao A. S., 2015 Phosphates from detergents and eutrophication of surface water ecosystem in India. Current Science 108 (7):1320–1325.
Magurran A. E., 2004 Ecological diversity and its measurement. Blackwell Publishing, Malden, MA, USA, 261 p.
Muhaemi R., Tuhumury W., Siegers, 2015 [The suitable of water quality for fish net culture of *Oreochromis niloticus*) in Lake Sentani, Sentani Timur District, Jayapura

Regency, Province of Papua]. Journal of Fisheries Development 1(2):45–58. [In Indonesian].
Lee C. S., Lee Y. C., Chiang H. M., 2016 Abrupt state change of river water quality (turbidity): Effect of extreme rainfalls and typhoons. Science of the Total Environment 557–558:91-101.
Munthe Y. V., Aryawati R., Isnanini, 2012 [Community structure and phytoplankton distribution in Sungsang Waters, South Sumatra]. Maspari Journal 4(1):122-130. [In Indonesian].
Neupane S., Vogel J. R., Storm D. E., Barfield B. J., Mittelstet A. R., 2015 Development of a turbidity prediction methodology for runoff–erosion models. Water Air Soil Pollution 226:415.
Putri W. A. E., Purwiyanto A. I. S., Fauziyah, Agustriani F., Suteja Y., 2019 Condition of nitrate, nitrite, ammonia, phosphate, and bod of Banyuasin River Estuary, South Sumatera. Jurnal Ilmu dan Teknologi Kelautan Tropis 11(1):65-74.
Qu L., Huang H., Xia F., Liu Y., Dahlgren R. A., Zhang M., Mei K., 2018 Risk analysis of heavy metal concentration in surface waters across the rural-urban interface of the Wen-Rui Tang River, China. Environmental Pollution 237:639-649.
Rahim A., Soeprobowati T. R., 2019 Water pollution index of Batujai Reservoir, Central Lombok Regency-Indonesia. Journal of Ecological Engineering 20(3):219–225.
Rintaka W. E., Hastuti A. W., Susilo E., Radiarta N., 2019 The use of Storet index to assess water quality in Perancak Estuary, Bali, Indonesia. IOP Conference Series: Earth and Environmental Science 246:012012.
Romanescu G. D., Miftode A. M., Pintilie C. C., Constantin I. S., 2016 Water quality analysis in mountain freshwater: Poaiana Uzului reservoir in the eastern Carpathians. Revista de Chimie 67(11):2318–2326.
Saraswati S. P., Ardion M. V., Hadisusanto S., 2019 Water quality index performance for river pollution control based on better ecological point of view (A case study in Code, Winongo, Gadjah Wong Streams). Journal of the Civil Engineering FORUM 5(1):47-57.
Patty S. I., 2014 Characteristics of phosphate, nitrate and dissolved oxygen in Gangga and Siladen Island Waters, North Sulawesi. Jurnal Ilmiah PLatax 2(2):74-84.
Soeprobowati T. R., Suwarno H., Gell P., Zawadski A., 2012 The diatom stratigraphy of Rawapening lake, implying eutrophication history. American Journal of Environmental Science 8 (3):334–344.
Soeprobowati T. R., Tandjung S. D., Sutikno, Hadisusanto S., Gell P., Hadiyanto, Suedy S. W. A., 2016 The water quality parameters controlling diatoms assemblage in Rawapening Lake, Indonesia. Biodiversitas 17(2):657-664.
Soeprobowati T. R., Suedy S. W. A., Hadiyanto, Lubis A. A., Gell P., 2018 Diatom assemblage in the 24 cm upper sediment associated with human activities in Lake Warna Dieng Plateau Indonesia. Journal Environment Technology & Innovation 10:314–323.
Soeprobowati T. R., Addadiyah N. L., Hariyati R., Jumari J., 2021 Physico-chemical and biological water quality of Warna and Pengilon Lakes, Dieng, Central Java. Journal of Water and Land Management 51(10-12):38-49.
Suhry H. C., Soeprobbowati T. R., Saraswati T. R., Jumari, 2020 [The water quality and Pollution index of Galela Lake]. Jurnal Ilmu Lingkungan 18(2):236-241. [In Indonesian].
Tuttle-Raycraft S., Ackerman J., 2019 Living the high turbidity life: The effects of total suspended solids, flow, and gill morphology on mussel feeding. Limnology and Oceanography 64(6):2526-2537.
Tyas D. S., Soeprobowati T. R., Jumari J., 2021 Water quality of Gatal Lake, Kotawaringin Lama, Central Kalimantan. Journal of Ecological Engineering 22(3):99-110.
Ustaoğlu F., Islam Md. S., 2020 Potential toxic elements in sediment of some rivers at Giresun, Northeast Turkey: A preliminary assessment for ecotoxicological status and health risk. Ecological Indicators 113:106237.

Vuuren S. J., Taylor J., Ginkel C., Gerber A., 2006 Easy identification of the most common freshwater algae, a guide for the identification of microscopic algae in South African freshwaters. North-West University, Department of Water Affairs and Forestry, Pretoria, 213 p.
Wu Y., Fang H., Huang L., Cui Z., 2020 Particulate organic carbon dynamics with sediment transport in the upper Yangtze River. Water Research 184:116193.
Yin Z., Bi X., Xu C., 2018 Ammonia-oxidizing archaea (AOA) play with ammonia-oxidizing bacteria (AOB) in nitrogen removal from wastewater. Archaea 8429145.
Yulius A., Prihantono J., Gunawan D., 2018 [Water quality study for aquaculture of grouper fish in Saleh Bay, Dompu Regency]. Jurnal Segara 14(1):57–68. [In Indonesian].
Zhang X., Wu Y., Liu X., Reis S., Jin J., Dragosits U., Van Damme M., Clarisse L., Whitburn S., Coheur P. F., Gu B., 2017 Ammonia emissions may be substantially underestimated in China. Environmental Science & Technology 251(21):12089-12096.
Zhang L., Nan Z., Xu Y., Li S., 2016 Hydrological impacts of land use change and climate variability in the headwater region of the Heihe River Basin, Northwest China. PloS One 11(6):e0158394.
Zwart M. C., Robson P., Rankin S., Whittingham M. J., McGowan P. J. K., 2015 Using environmental impact assessment and post-construction monitoring data to inform wind energy developments. Ecosphere 6(2):26.
*** APHA 2012 Standard methods for the examination of water and wastewater. 22th edition. APHA-AWWA-WEF, Washington D.C., 1360 p.
*** BPSKLT, Badan Pusat Statistik Kabupaten Lombok Timur, 2022 [East Lombok Regency in number 2022]. Badan Pusat Statistik Kabupaten Lombok Timur. [In Indonesian].
*** Government Regulation Number 35 of 1991 about river.
*** Government Regulation Number 22 of 2021, concerning the implementation of environmental protection and management.
*** Environment Minister of Indonesia Decree No. 115/2003 regarding the guideline for water quality status.
*** SNI 6989.57, 2008 Method for surface water sample collection. Indonesian National Standard.
*** United Nations, 2016 The sustainable development goals report 2012. United Nations New York, 56 p.

Received: 07 September 2021. Accepted: 20 July 2022. Published online: 10 August 2022.
Authors:
Fakhrurrozi, Master Program of Biology, Faculty Science and Mathematics, Diponegoro University, Prof Soedarto Street, Tembalang, Semarang, Indonesia, e-mail: rozipejanggik@gmail.com
Tri Retnaningsih Soeprobowati, Department Biology, Faculty Science and Mathematics, Diponegoro University, Semarang, Indonesia, e-mail: trsoeprobowati@live.undip.ac.id
Jumari Jumari, Master Program of Biology, Faculty Science and Mathematics, Diponegoro University, Semarang, Indonesia, e-mail: jumariundip@live.undip.ac.id

How to cite this article:
Fakhrurrozi, Soeprobowati T. R., Jumari J., 2022 The water quality index and phytoplankton communities of Kokoh Putih River, Sembalun, East Lombok, Indonesia. AACL Bioflux 15(4):2025-2040.