E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2021; 9(4): 249-254

www.fisheriesjournal.com
Received: 28-05-2021
Accepted: 30-06-2021

Cahyo Shifaris Putrandy
Department of Fisheries, Faculty of Fisheries and Marine Sciences, Padjadjaran University, Bandung-Sumedang KM 21, Jatinangor, Indonesia

Zahidah
Department of Fisheries, Faculty of Fisheries and Marine Sciences, Padjadjaran University, Bandung-Sumedang KM 21, Jatinangor, Indonesia

Herman Hamdani
Department of Fisheries, Faculty of Fisheries and Marine Sciences, Padjadjaran University, Bandung-Sumedang KM 21, Jatinangor, Indonesia

Heti Herawati
Department of Fisheries, Faculty of Fisheries and Marine Sciences, Padjadjaran University, Bandung-Sumedang KM 21, Jatinangor, Indonesia

Corresponding Author:
Cahyo Shifaris Putrandy
Department of Fisheries, Faculty of Fisheries and Marine Sciences, Padjadjaran University, Bandung-Sumedang KM 21, Jatinangor, Indonesia

Determination of the trophic status of Jatigede reservoir using the trophic state index method

Cahyo Shifaris Putrandy, Zahidah, Herman Hamdani and Heti Herawati

Abstract
This study aims to determine the trophic status of the Jatigede Reservoir based on the Trophic State Index. The study was done from August 2020 to March 2021. This study used a survey method. Determination of the research location is done by the purposive sampling method. Sampling was carried out at six stations representing three reservoir zoning. The parameters analyzed were the physical and chemical parameters of the waters, namely water transparency, temperature, pH, dissolved oxygen (DO), total phosphorus, nitrate and chlorophyll-a. The trophic status was measured by the Trophic State Index method. The average value of the trophic state index in the Jatigede Reservoir ranges from 57.82-60.35, so that it is classified as eutrophic waters. The trophic status during the study was influenced by several physical and chemical parameters measured at each observation station.

Keywords: trophic status, trophic state index, water quality, Jatigede reservoir

1. Introduction
Trophic status is an indicator of the fertility level of water that can be measured from the nutrients and brightness levels and other biological activities that occur in a water body. Trophic status is often used to classify aquatic ecosystems based on their biological productivity [1]. Fertility status or trophic status of waters can be determined through various approaches, both biologically and a combination of biological and water quality (physical and chemical parameters) [2]. That is based on the understanding that changes in trophic levels are marked by changes in water quality, including changes in biological conditions, in this case, the presence of phytoplankton [3-5]. The use of three approaches will give more representative results than using only physical-chemical parameters. The values obtained are unstable because the water's physical and chemical parameters change rapidly due to changes in season or weather over time, while the biological parameters are relatively stable. Nevertheless, often between one approach and another give different results [6]. Therefore, the application that uses the three approaches is the TSI (Trophic State Index) method.
The TSI method only uses three water quality parameters, namely transparency, total phosphorus, and chlorophyll-a, because these three parameters significantly affect the eutrophication process [7]. The choice of total phosphorus in the calculation is because total phosphorus is a limiting nutrient for aquatic ecosystems. Besides, that anthropogenic activities can increase the total phosphorus concentration in the waters. The choice of chlorophyll-a is because chlorophyll-a can describe the biomass of the phytoplankton population. The choice of transparency measurement using a secchi disc is based on the density of algae that can affect water transparency. These three parameters are used to determine the status of eutrophication because these parameters are correlated with each other.
A reservoir is an artificial lake that dams rivers' flow to form a flooded water ecosystem, which was previously a flowing water ecosystem. The reservoir water source mainly comes from surface runoff plus direct rainwater. In general, river flows that enter the reservoir carry water containing nutrients from the washing of the surface soil layer from agricultural activities so that the reservoir experiences nutrient enrichment. That happened to the Jatigede Reservoir because the Jatigede Reservoir was built on the plantation and residential land [8]. After the inundation period, many inputs of wastewater discharge from the surrounding residential areas are carried away by the river flow [9], thus making Jatigede Reservoir has the potential for high nutrient content. Distribution of nitrate, nitrite, ammonia and phosphate

values in the waters of the Jatigede Reservoir is uneven. That is because the Jatigede Reservoir has several tributaries that drain into the reservoir [10]. If the nutrients that enter the Jatigede Reservoir exceed the threshold, it will accelerate the eutrophication process. Therefore, it is crucial to know the trophic status of the waters of the Jatigede Reservoir. Determination of the trophic status of the Jatigede Reservoir using the Trophic State Index method to determine the trophic status of the Jatigede Reservoir based on the Trophic State Index.

2. Materials and Methods

The research was done from August 2020 - February 2021. Samples were taken at six stations with six replications. The selection of stations is based on water input, BOD levels, and six stations (Figure 1) representing three reservoir zoning, namely riverine zone, transition zone, and lacustrine zone. Stations 1 and 2 represent the riverine zone that gets water input from the Cimanuk, Cialing, Cibuntu, Cimuja, and Cijajaway rivers. Stations 3 and 4 represent the transition zone, which is used as a floating net cage area. Stations 5 and 6 represent lacustrine zones and outlets where there are no human activities such as cultivation and fishing. Sampling was carried out in the morning using a water sampler, and then in situ measurements were made for transparency, pH, temperature, and DO, for *ex-situ* measurements.

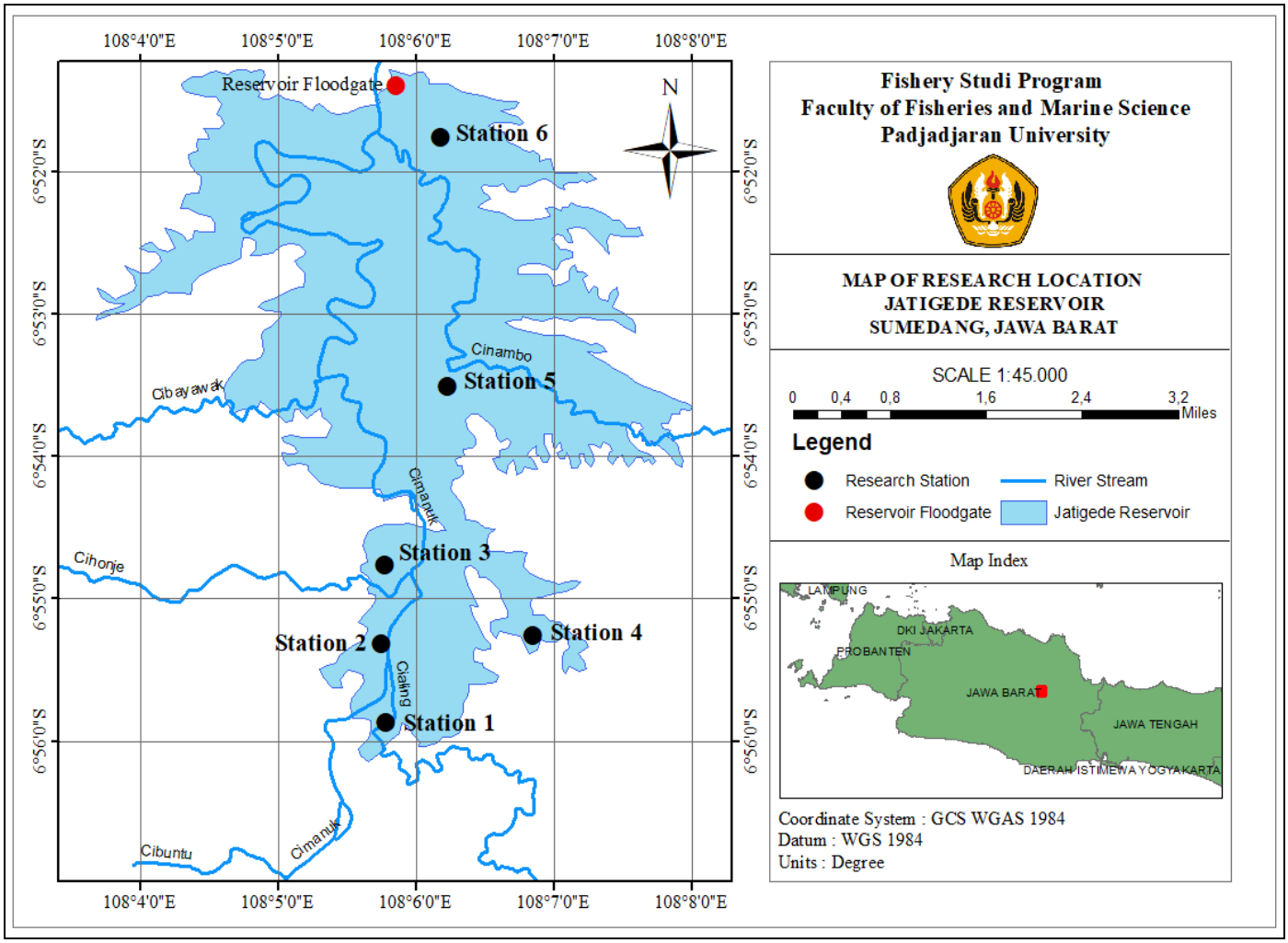

Fig 1: Research Location Map

2.1 Measurement of trophic state index parameters

Measurement of water transparency (m) is measured using a secchi disc, that is, when the black and white colours on the secchi disc disappear from view.

$$\text{Transparency (m)} = \frac{D1 + D2}{2}$$

D1 is the depth when the secchi disc is gone, and D2 is the depth when the secchi disc is visible again.

The concentration of chlorophyll-a (mg/L) in water samples from each station was measured using the spectrophotometric method with a spectrophotometer to measure the absorbance value in each sample. This method is based on three wavelengths (trichromatic), each of which is the maximum absorption for chlorophyll-a in acetone solvent. Calculation of the concentration of chlorophyll-a is calculated by the formula [11, 12] as follows:

Chlorophyll-a (mg/L) = (Ca×v)/(V×L)

Information:

v	=	Volume of Acetone used (ml)
V	=	Volume of filtered water for extraction (L)
L	=	Length of cuvette (cm)
Ca	=	(11.6 D665) – (1.31 D645) – (0.14 D630)
D665	=	Optical density at a wavelength of 665 nm
D645	=	Optical density at a wavelength of 645 nm
D630	=	Optical density at a wavelength of 630 nm

The measurement of the phosphate concentration was measured spectrophotometrically using the ammonium molybdate method. Then the phosphate concentration was converted to total phosphorus using the formula [13, 14] to convert the phosphate concentration to total phosphorus as follows:

$$\text{Total Phosphorus } \left(\frac{\text{mg}}{\text{L}}\right) = \text{Phasphate } \times 0{,}3262$$

The value of 0.3262 is equal to 1 mg/L of phosphate. The value is based on the molecular weight in phosphate concentration (PO_4) divided by the molecular weight of phosphorus (P).

The three parameters (transparency, chlorophyll-a, and total phosphorus) were used to determine the trophic status based on the Trophic State Index method. TSI calculation can be calculated by the formula proposed by Carlson [7] as follows:

$$\text{TSI (SD)} = 60 - 14.41 \ln (\text{SD})$$
$$\text{TSI (CHL)} = 30.6 + 9.81 \ln (\text{CHL})$$
$$\text{TSI (TP)} = 4.15 + 14.42 \ln (\text{TP})$$

$$\text{TSI} = \frac{\text{TSI (SD)} + \text{TSI (CHL)} + \text{TSI (TP)}}{3}$$

Information:
SD = Secchi disc(m)
CHL = Chlorophyll-a (µg/L)
TP = Total phosphorus (µg/L)

The final value obtained as the average TSI along with the other three parameters is then used to determine and classify the trophic status of the Jatigede Reservoir based on the TSI criteria with an index ranging from 0-100, which is shown in Table 1 as oligotrophic, mesotrophic, eutrophic, and hypereutrophic aquatic ecosystems.

Table 1: Classification of reservoir trophic status based on TSI [15]

TSI	Trophic Status	Secchi Depth (SD)	Total Phosphorus (TP)	Chlorophyll-a (Chl-a)
0 – 40	Oligotrophic	>8 – 4	0 – 12	0 – 2.6
40 – 50	Mesotrophic	4 – 2	12 – 24	2.6 – 7.3
50 – 70	Eutrophic	2 – 0.5	24 – 96	7.3 – 56
70 – 100+	Hypereutrophic	0.5 - < 0.25	96 – 384 +	56 – 155 +

3. Results and Discussion

3.1 General Parameters

The values of physical and chemical parameters in the waters of the Jatigede Reservoir during the study are listed in Table 2

Table 2: Physical and chemical parameters in the waters of

Unit Parameters	station					
	1	2	3	4	5	6
Physical Parameters						
Temperature (°C)	28.9±0.6	28.7±0.7	29±0.4	28.7±0.5	28.7±0.7	28.8±0.8
Chemical Parameter						
Acidity	7.12±0.26	7.45±0.57	7.1±0.26	7.01±0.1	7.12±0.3	7.03±0.13
Dissolved Oxygen (mg/L)	5.38±0.66	5.2±0.53	5.07±0.76	5.58±0.7	5.77±0.95	5.65±0.9
Nitrate (mg/L)	0.023±0.004	0.028±0.008	0.025±0.007	0.025±0.011	0.023±0.009	0.017±0.008

3.1.1 Temperature

Based on Table 2, the temperature values obtained are in the range of 28.7 °C–29 °C. The temperature value obtained can still be stable because there are no fluctuations that are too high. Following the statement [16], temperature fluctuations in tropical waters throughout the year generally have air temperature fluctuations that are not too high so that the temperature in the waters does not experience high-temperature changes. However, the temperature difference can be caused by several factors. The water temperature is influenced by several factors, such as the presence of shade (e.g. trees or aquatic plants), wastewater entering water bodies, solar radiation, air temperature, weather, and climate [17, 18]. The temperature results obtained are still in the optimum temperature for phytoplankton life because the optimum temperature for phytoplankton life in waters is around 20 °C-30 °C. In addition to phytoplankton, the temperature in the Jatigede Reservoir is also suitable for the growth of several types of fish, because in general, fish can grow well in the temperature range of 25 °C-32 °C [19, 20].

3.1.2 Acidity

The data on the acidity (pH) in Table 2 obtained during the study at the six stations of the Jatigede Reservoir obtained values between 7.01-7.45. The pH value obtained is influenced by several things, one of which is the activity of phytoplankton, such as photosynthesis and respiration [21]. The pH measurement results are still within the appropriate range for the life of freshwater biota. According to Berutu statement, that the ideal pH for freshwater biota life is around 6.8-8.5. In addition, the pH measurement results obtained indicate that the Jatigede Reservoir is fertile and productive water because, waters that have a pH value between 6-9 water with high fertility are classified as productive [23].

3.1.3 Dissolved Oxygen

Based on the results of dissolved oxygen measurements in Table 2, the dissolved oxygen obtained at six stations in the Jatigede Reservoir ranged from 5.07-5.77 mg/L. The results of the dissolved oxygen measurement indicate that the Jatigede Reservoir is still included in good waters and has a low level of pollution. Waters can be categorized as good waters and have low pollution levels if the dissolved oxygen value
is > 5 mg/L [24]. The value of dissolved oxygen in the Jatigede Reservoir does not exceed the standard value of dissolved oxygen for natural waters. Dissolved oxygen in natural waters is usually less than 10 mg/L [25].

3.1.4 Nitrates

Based on Table 2, the nitrate values obtained at six stations of the Jatigede Reservoir ranged from 0.017-0.028 mg/L. The results of nitrate measurements in the Jatigede Reservoir are not yet in the optimal category for phytoplankton life. Optimal phytoplankton growth requires a nitrate value in the range of 0.9-3.5 mg/L [26, 27]. In addition, the nitrate value obtained indicates that the fertility level of the waters in the Jatigede Reservoir is classified as oligotrophic waters. Following the statement of Davis and Cornwell [28], oligotrophic waters have nitrate values between 0–1 mg/L. So that the nitrate value in the Jatigede Reservoir can be categorized into waters with low fertility or oligotrophic levels because the average value of the measurements obtained is 0.017-0.028 mg/L (<1 mg/L).

3.2 Trophic Status of Jatigede Reservoir

3.2.1 TSI Parameters

The results of the parameter measurements used to calculate the TSI can be seen in Table 3.

Table 3: TSI Calculation Parameters

Parameter	Station					
	1	2	3	4	5	6
Transparency (m)	0.75±0.2	0.71±0.19	1±0.32	0.88±0.2	1.01±0.24	1.06±0.23
Chlorophyll (mg/m3)	19.36±3.46	14.29±1.83	15.5±3.18	14.14±4.05	14.37±2.61	12.75±2.27
Total Phosphorus (mg/L)	0.031±0.006	0.03±0.003	0.03±0.007	0.029±0.007	0.031±0.005	0.03±0.008

3.2.1.1 Transparency

Based on table 3, the transparency value obtained is in the range of 0.71-1.06 m., the transparency data in table 3 obtained during the study, shows that the transparency of the waters of the jatigede reservoir varies. Varied transparency values can be caused by several things, including the number of suspended solids, the amount of phytoplankton biomass, differences in measurement time, and weather [29]. In addition, the transparency value obtained shows that the fertility level of the waters in the jatigede reservoir is included in the category of eutrophic waters. That is following the statement of Carlson [15], eutrophic waters have a transparency value between 0.5–2 m. So that the value of transparency in the jatigede reservoir can be categorized into waters that have a high fertility level or are eutrophic. Even so, the measurement results include optimal transparency for aquatic biota life because good transparency for aquatic biota is transparency whose value is > 0.45 m [30].

3.2.1.2 Chlorophyll-a

Based on table 3, the chlorophyll-a values obtained at six stations in the jatigede reservoir ranged from 12.75-19.36 mg/m^3. The difference in the value of chlorophyll-a at each station can be influenced by several factors, especially nutrients. The level of chlorophyll-a is closely related to the supply of nutrients. Besides that, the results of chlorophyll-a measurements in the jatigede reservoir describe these waters as eutrophic waters [31]. That is following the opinion of Henderson-Sellers and Markland [32], that chlorophyll-a can describe the trophic status of a water. According to Carlson [15], water fertility status based on the value of chlorophyll-a is classified as eutrophic if it has a chlorophyll-a value of 7.3-56 mg/m^3.

3.2.1.3 Total Phosphorus

Based on table 3, the total phosphorus value obtained at six stations of the jatigede reservoir ranged from 0.029-0.031 mg/l. The measurement of total phosphorus in the Jatigede reservoir includes waters with a high total phosphorus value. The high value of total phosphorus in the Jatigede reservoir is due to the input of nutrients from the activities of the surrounding community and the input of water from the cimanuk river and several tributaries. These rivers pass through residential areas and agricultural land that contains high nutrients [33]. Based on the measurement results of total phosphorus, the total phosphorus value obtained indicates that the fertility level of the waters in the jatigede reservoir is included in the category of eutrophic waters. If the total phosphorus value in the waters is 0.024–0.096 mg/l, the waters are classified as having a high fertility level (eutrophic) [15]. Even though it is classified as eutrophic waters, the total phosphorus value obtained is still within safe limits from phytoplankton blooms. Following the statement [34] the acceptable range of total phosphorus for a water body is 0.01-0.04 mg/L.

3.2.2 Trophic State Index

Trophic State Index measurement results can be seen in Table 4

Table 4: The average value of the Trophic State Index

Parameter	Station						Parameter average
	1	2	3	4	5	6	
Chlorophyll-a	59.53	56.63	57.30	56.24	56,60	55.43	56.95
Total Phosphorus	53.37	53.02	52.97	52.43	53.15	52.91	52.98
Secchi Disk	64.57	65.58	60.66	62.18	60.24	59.46	62.12
TSI	59.16	58.41	56.98	56.95	56.66	55.94	

Based on the results of the calculation of TSI values in Table 4, the TSI values obtained at six stations in Jatigede Reservoir ranged from 57.82-60.35. The TSI value between stations is still in one category. That is because each of the measured parameters (chlorophyll-a, total phosphorus and transparency) has a value in the same category, namely eutrophic. The parameter that significantly affects the high TSI value in the Jatigede Reservoir is transparency because the value of transparency was low during the study, ranging from 0.71-1.06 m (< 2.5 m). The measurement of trophic status using TSI between parameters does not always have the same results [15]. In this case, the TSI SD is classified as moderately eutrophic, while the other two parameters are classified as mild eutrophic. The difference is the turbidity caused by non-

algae particles and the colour of the bottom waters. However, because these three are interrelated, the other two main parameters also have a reasonably high value. That is explained by [35] that total phosphorus is a limiting nutrient for phytoplankton growth so that total phosphorus will affect the value of chlorophyll-a in the waters. The high density of phytoplankton or the high value of chlorophyll-a can increase turbidity to reduce the transparency of water.

The calculation of the TSI value is used to determine the fertility level of the waters in the Jatigede Reservoir. Based on these measurements, it can be concluded that the waters in the Jatigede Reservoir are categorized as mild to moderately eutrophic waters. That is following the opinion [7] based on the results of the TSI obtained, the level of water fertility are grouped into seven categories, including ultra oligotrophic (<30), oligotrophic (30–40), mesotrophic (40–50), mild eutrophic (50–60), moderate eutrophic (60 -70), severe eutrophic (70-80), and hypereutrophic (>80).

Overall, both the TSI value and the TSI value per parameter show that the TSI value decreases from station 1 to station 6 even though it is still in the same trophic status category (eutrophic). The higher TSI value at station 1 is because this station is the inlet of the Jatigede Reservoir, which carries waste, and the surrounding area is a residential and agricultural area that contributes nutrients to enter the reservoir waters. That is following the opinion of [36], which states that. the presence of organic matter that enters the waters comes from increased activities on land, such as agricultural activities and household activities that enter water bodies that affect the ups and downs of nutrients.

4. Conclusion

Based on the results of research that has been carried out in the Jatigede Reservoir, it can be concluded that the TSI value calculated using the Trophic State Index method in the Jatigede Reservoir is 57.82-60.35, so that the trophic status of the Jatigede Reservoir based on the Trophic State Index is mild to moderately eutrophic.

5. References

1. Zulfia N, Aisyah. Status Trofik Perairan Rawa Pening Ditinjau Dari Kandungan unsur hara (NO_3 dan PO_4) serta klorofil-a. Bawal 2013;5(3):189-199.
2. Pratiwi NTM, Rahman A, Hariyadi S, Ayu IP, Iswantari A. Relationship between trophic states and nutrients load in waters surrounding Samosir Island, Lake Toba, North Sumatera. Lake Ecosystem Health and Its Resilience: Diversity and Risks of Extinction. Proceedings of the 16th World Lake Conference 2017, 469-475.
3. Ayoade AA, Osuala BO, Adedapo TA. Physico-chemical parameters, chlorophyll a and phytoplankton community as trophic state indices of two tropical lakes, southwestern Nigeria. Eur Asian Journal of Bio Sciences, 2019;13(1):15-22.
4. Díaz S, Purvis A, Cornelissen J, Mace G, Donoghue M, Ewers R *et al*. Functional Traits, The Phylogeny of Function, and Ecosystem Service Vulnerability. Ecology and Evolution 2013;3(9):2958-2975.
5. Rakocevic-Nedovic J, Hollert H. Phytoplankton community and chlorophyll a as trophic state indices of Lake Skadar (Montenegro, Balkan). Environmental Science and Pollution Research 2005;12(3):146-152.
6. Sitorus R. Status Kesuburan Waduk Koto Tibun Kabupaten Kampar Provinsi Riau Berdasarkan Trophic State Index (TSI). Jurnal Online Mahasiswa Faperika 2018.
7. Carlson, Robert E. A trophic state index for lakes. Limnology and Oceanography 1977;22(2):361-369.
8. Purnama Y Dampak. Pembangunan Waduk Jatigede Terhadap Kehidupan Sosial Budaya Masyarakatnya the Impact of Build Jatigede Dam Through Social and Cultural Life of Society. Patanjala 2015;*7*(1):131-146.
9. Nugroho. Distribusi Serta Kandungan Nitrat Dan Fosfat Di Perairan Danau Rawa Pening. Bioma 2014;3(1):27-41.
10. Herawati H, Kurniawati N, Maulina I, Zahidah, Sahidin A. Water Quality Status of Jatigede Reservoirs In Sumedang. Global Scientific Journals 2018;6(12):181-188.
11. Wetzel RG, Likens GE. Limnological Analysis (Second). Springer Verlag 1991.
12. Zahidah. Produktivitas Perairan. Universitas Padjadjaran 2020.
13. Kochary SAY. Assessment of Selected Physico-Chemical Parameters of Ground Water in Direct Contact With Septic Tanks: Experimental Modeling. The Journal of The University of Duhok 2017;20(1):231-240. https://doi.org/10.26682/sjuod.2017.20.1.20
14. Jaka R, Chandra D, Ain C, Febrianto S, Rudiyanti S. Analisis Status Trofik Perairan Waduk Jatibarang Dengan Menggunakan Data Citra Satelit Sentinel-2A. 2020;16(2):115-122.
15. Carlson RE. Estimating Trophic State. Lakeline 2007;27:25-28.
16. Barus TA. Pengantar Limnologi Studi Tentang Ekosistem Daratan. USU Press 2004.
17. Chin DA. Water-Quality Engineering in Natural Systems. John Wiley & Sons, Inc 2006.
18. Boyd CE. Water Quality: An Introduction (Second Edi). Springer 2015.
19. Maresi SRP, Priyanti P, Yunita E. Fitoplankton sebagai Bioindikator Saprobitas Perairan di Situ Bulakan Kota Tangerang. AL-Kauniyah: Jurnal Biologi 2016;8(2):113-122.
20. Pujiastuti P, Ismail B. Kualitas dan Beban Pencemaran Perairan Waduk Gajah Mungkur. Jurnal Ekosains 2013;V(1):59-75.
21. Boyd CE. Water Quality in Ponds for Aquaculture. Agriculture Experiment Station. Auburn University 1990.
22. Berutu WP. Produktivitas Primer Perairan Danau Toba Kecamatan Silalahi Kabupaten Dairi Provinsi. Sumatera Utara. Universitas Sumatera Utara 2018.
23. Odum EP. Fundamentals of ecology (Third). W. B. Saunders Company 1971.
24. Salmin. Oksigen Terlarut. (DO) Dan Kebutuhan Oksigen Biologi (BOD) Sebagai Salah Satu Indikator Untuk Menentukan Kualitas Perairan. Oseana 2005;30(3):21-26.
25. Effendi H. Telaah Kualitas Air (Pertama). Kanasius 2003.
26. Mackentum KM. The Practice of Water Pollution Biology. United States Departement of Interior, Federal Water Pollution Control Administration, Division of Technical Support 1969.
27. Yuliana. Kelimpahan Fitoplankton Di Perairan Maitara, Kota Tidore Kepulauan. Jurnal Perikanan. 2008;10(2):232–241.
28. Davis M, Cornwell DA. Introduction to Environmental Engineering. Auburn University 1991.

29. Stednick JD, Hall EB. Applicability of Trophic Status Indicators To Colorado Plains Reservoirs 2001, 195.
30. Asmawi S, Ekologi Ikan. Departemen Pendidikan dan Kebudayaan. Fakultas Perikanan Universitas Lambung Mangkurat 1985.
31. Sihombing RF, Aryawati R, Hartoni. Kandungan Klorfil-a Fitoplankton di Sekitar Perairan Desa Sungsang Kabupaten Banyuasin Provinsi Sumatera Selatan. Maspari Journal 2013;5(1):34-39.
32. Henderson-Sellers B, Markland HR. Decaying Lakes: The Origins and Control of Cultural Eutrophication. John Willey & Sons Ltd 1987.
33. Subarma U, Purnomo PW, Hutabarat S. Evaluasi Kualitas Air Sebelum dan Sesudah Memasuki Waduj Jatigede, Sumedang. Diponegoro Journal of Maquares. 2014;3(4):132-140.
34. EPA AEP. Total Phosphorus. Environmental Protection Agency 2014;415:3432.
35. Opiyo S, Getabu AM, Sitoki LM, Shitandi A, Ogendi GM. Application of the Carlson's Trophic State Index for the Assessment of Trophic Status of Lake Simbi Ecosystem, a Deep Alkaline-Saline Lake in Kenya. SSRN Electronic Journal 2019;7(4):327-333.
36. Faizal A, Jompa J, Nessa N, Rani C. Dinamika Spasio-Temporal Tingkat Kesuburan Perairan Di. Jurnal Ilmu Kelautan 2011;3(2):1-16.