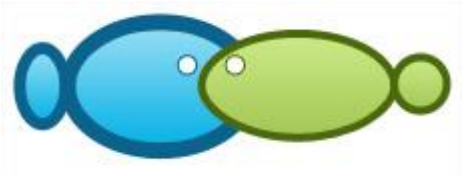

Trophic level status of Jatigede Reservoir based on phosphate concentration

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Abstract. The decline of water quality in Jatigede Reservoir is mainly caused by agricultural activities and settlements around the waters. This condition causes an increase in nutrients, such as phosphate, so that there is an increase in water fertility. This research aimed to determine the level of fertility based on the concentration of phosphate in the Jatigede Reservoir, Sumedang, Indonesia. The study was conducted from August 2020 to March 2021. This research used the survey method with purposive sampling to determine the research location. Sampling locations were established at six stations selected based on the input of river water flowing into the body of water and representing all water zones. The parameters observed included physical parameters (temperature and transparency) and chemical parameters (phosphate, pH, BOD_5, DO, and nitrate). The research results show that the fertility level of Jatigede Reservoir can be included in waters with eutrophic fertility levels based on the Indonesian Minister of Environment Regulation No. 28 of 2009.

Key Words: eutrophic, nutrient, water quality, water fertility level.

Introduction. One of the main problems related to aquatic resources is water quality, which continues to decline from year to year. Agricultural and domestic activities spoil water resources. This condition can cause disturbances, damage, and danger to organisms that depend on the water (Effendi 2003). Cases of decreasing water quality have occurred in several parts of Indonesia, including in Sumedang Regency. Jatigede Reservoir is a reservoir that stems from the flow of the Cimanuk River, located in the Sumedang Regency. The surrounding community uses the Cimanuk watershed for local water companies' availability, agricultural, and fishery activities. These activities impact water quality (Sari et al 2014).

Water fertility is one of the supporting factors in determining the quality of water (Ayoade et al 2019) and is closely related to fishery potential (Permanasari et al 2017). The amount of nutrient content, especially phosphate (PO_4^{3-}), affects the population of aquatic biota and strongly influences the level of fertility (Mustofa 2015) of waters. The level of water fertility can be determined by using the concentration of phosphate, which is a significant limiting factor in productive and unproductive waters (Kadim et al 2017). According to the Indonesian Government Regulation Number 22 of 2021, the phosphate concentration in the waters of class II is 0.03 mg L^{-1} and of class III is 0.1 mg L^{-1}. In addition, according to the Regulation of the Indonesian Minister of the Environment Number 28 of 2009, the trophic status categories based on phosphate concentration are divided into 4, namely oligotrophic (≤0.65 mg L^{-1}), mesotrophic (≤0.75 mg L^{-1}), eutrophic (≤1 mg L^{-1}), and hypertrophic (>1 mg L^{-1}).

Based on the Decree of the Indonesian Minister of Public Works No. 267/KPTS/M/2010, water quality in the Cimanuk-Cisanggarung River area is classified as poor. All rivers around Cimanuk-Cisangarung carry high concentrations of dissolved solids, and present chemical oxygen demand (COD) and biochemical oxygen demand (BOD_5) values that exceed the quality standard. In addition, agricultural and plantation activities cause an increase in nutrients, one of which is phosphate, which exceeds the quality standard (Subagiyo et al 2019). This, of course, directly affects the fertility of the Jatigede Reservoir because it receives water input directly from the Cimanuk River. It is important to evaluate the quality, which can be used as the basis for the management of the Jatigede Reservoir. Currently, there is limited information related to the fertility level of Jatigede Reservoir.

Hence, this research aimed to investigate the level of fertility based on the concentration of phosphate and evaluate physical (temperature and transparency) and chemical (acidity, BOD_5, dissolved oxygen, and nitrates) quality of the Jatigede Reservoir, Sumedang, Indonesia.

Material and Method. The research was carried out from August 2020 to March 2021 to represent two seasons: dry and rainy seasons. The method used in this research is a comparative descriptive method comparing physical and chemical parameters (Table 1) with the quality standards of the Indonesian Government Regulation No. 22 of 2021, based on classes II and III, to determine water quality in the Jatigede Reservoir for fisheries. Physical parameters of water quality that were measured during the research included temperature and transparency. Chemical parameters of water quality that were measured are phosphate, acidity (pH), BOD_5, dissolved oxygen (DO), and nitrate.

Table 1

Measuring methods of physical and chemical parameters

Parameters	*Unit*	*Method*
Temperature	℃	Potentiometry, using a thermometer
Transparency	cm	Visual, using a Secchi disk
pH	-	Potentiometry, using a pH meter
BOD_5	mg L^{-1}	Titration
DO	mg L^{-1}	Potentiometry, using a DO meter
Nitrate	mg L^{-1}	Spectrophotometry
Phosphate	mg L^{-1}	Spectrophotometry

Meanwhile, the assessment of the fertility of Jatigede Reservoir water was based on the distribution of phosphate concentrations and compared with the Regulation of the Minister of the Environment Number 28 of 2009. Determination of phosphate concentration was carried out using the UV-Vis spectrophotometric method. 25 mL of water sample were taken from each depth and put into an Erlenmeyer, then 0.25 mL of ammonium molybdate solution and 1 drop of $SnCl_2$ were added. The solution was stirred and allowed to react for 7 min, then the solution was placed into a cuvette and the absorbance of the solution was read at a wavelength of 650 nm.

The determination of the sampling locations used the purposive sampling technique. Sampling was carried out eight times in the wet and dry seasons, with a frequency of once a month. Water sampling was performed at three depths (surface, half-depth compensation, and compensation depth). The samples were collected with a water sampler, then the water samples were placed in a container for on-site analysis (pH, temperature, transparency and DO). Then, some samples were placed in 1 L containers stored in the refrigerator for BOD_5, nitrate, and phosphate analysis at the Laboratory of Fisheries Resources Management, Faculty of Fisheries, and Marine Science Unpad. The sampling stations were selected based on the input of river water flowing into the water body and representing the entire water zone (Figure 1). Stations 1 and 2 illustrate the riverine zone, stations 3 and 4 represent the transition zone, and stations 5 and 6 represent the lacustrine and outlet zones.

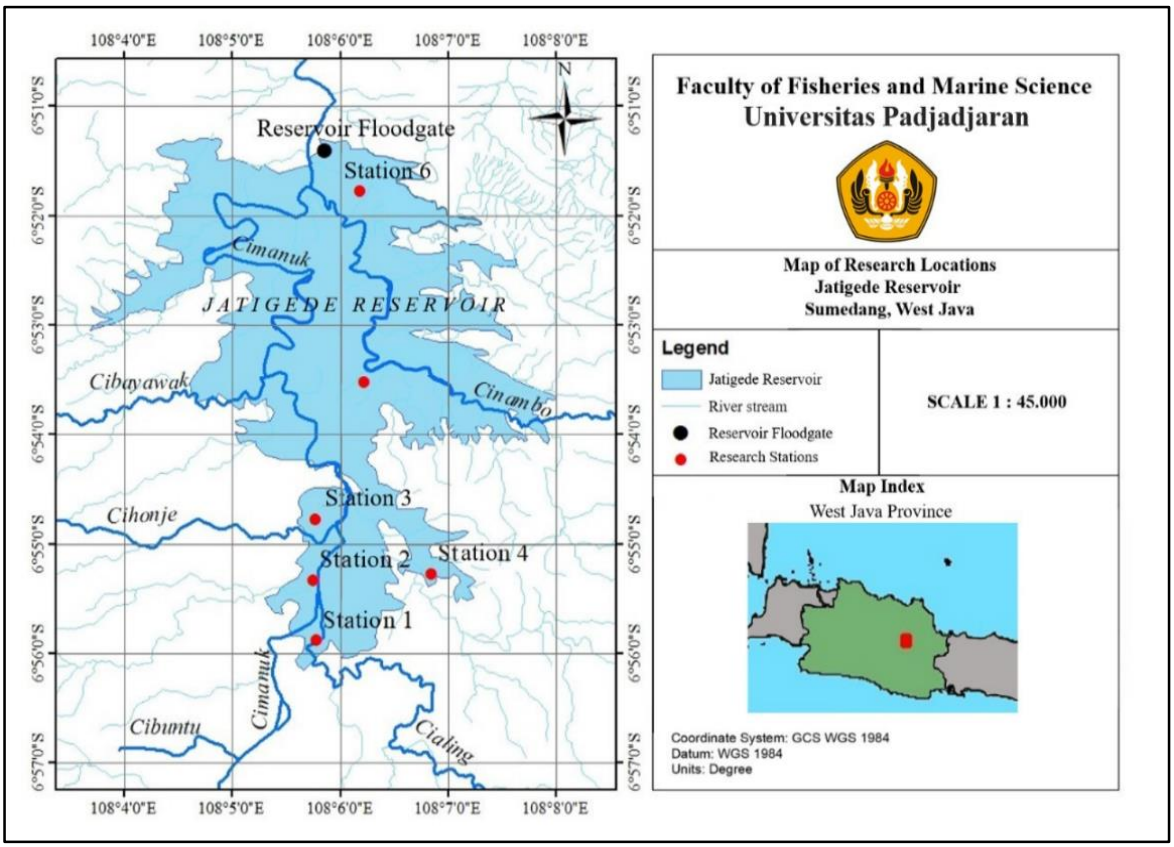

Figure 1. Research location.

Results and Discussion

Physical parameters. The average results of measuring water quality physical parameters are presented in Table 2.

Table 2

Physical parameters of Jatigede Reservoir

Parameters		*Station*					
		1	*2*	*3*	*4*	*5*	*6*
Temperature (°C)	S	28.88 ±0.59	28.72 ±0.69	29.02 ±0.38	28.73 ±0.5	28.68 ±0.74	28.77 ±0.78
	H	28.6 ±0.55	28.38 ±0.7	28.6 ±0.35	28.3 ±0.5	28.25 ±0.69	28.37 ±0.76
	C	28.27 ±0.49	28.03 ±0.69	28.42 ±0.2	28.18 ±0.65	27.88 ±0.69	27.88 ±0.74
Transparency (cm)		74.9 ±20	70.5 ±19.35	99.58 ±31.78	87.67 ±19.67	100.83 ±24.46	106 ±23.43

Note: S - surface; H - half compensation depth; C - compensation depth.

Temperature. The temperature values of Jatigede Reservoir ranged from 26.6 to 29.7°C. The temperature in Jatigede Reservoir is included in the optimum temperature for the life of water organisms. The optimum temperature for the life of phytoplankton organisms in the waters is 20-30°C, while fish can grow well in a temperature range of 25-32°C (Maresi et al 2016). The distribution of temperature in the waters is influenced by several factors, including the intensity of sunlight, season, and weather (Meliala et al 2019). The intensity of light entering the waters and cloud cover are two factors that affect the temperature value in the waters of the Jatigede Reservoir. Based on research results, the temperature value in the Jatigede Reservoir is under the quality standard of the Indonesian Government

Regulation No. 22 of 2021 concerning implementing environmental protection and management for classes II and III is 20-30°C, with a deviation value of 3 from the average environmental temperature.

Transparency. Transparency values obtained during the research ranged from 38 to 150 cm. The value of transparency in the Jatigede Reservoir varies greatly. The value could be influenced by the presence of suspended solids that enter the water body through the river flow. Rivers flowing into water bodies have colloids and fine particles that cause turbidity and result in a lack of light penetration into the waters (Ali & Aida 2016).

Chemical parameters. The chemical parameters of water quality measured during the research included phosphate, acidity (pH), BOD_5, dissolved oxygen (DO), and nitrate. The average results of the measurements are presented in Table 3.

Phosphate. Based on the research results conducted in Jatigede Reservoir, the phosphate concentration ranged from 0.054 to 0.137 mg L^{-1}. The phosphate measurements in Jatigede Reservoir were carried out at six stations, as shown in Figure 2. The half-compensated depth from station 2 has the highest phosphate concentration of 0.106±0.02 mg L^{-1}, while the lowest phosphate concentration is at station 4, surface, with a concentration of 0.90±0.023 mg L^{-1}.

The high phosphate concentration at station 2 was due to the waste accumulation from the Cimanuk River, Cimuja River, and Cijajaway River. This is due to the contribution of nutrients from agricultural and residential activities that enter through the river. According to Indrayani et al (2015), the high concentration of phosphate is influenced by nutrient intake from the actions of residents around the waters. The low phosphate concentration at station 4, surface, is due to phytoplankton making good use of it for growth. This result was also observed by Zahidah et al (2013) in Situ Cisanti Bandung, where the low phosphate concentration has resulted from abundant phytoplankton.

The concentrations of phosphate at stations 4 and 5 increased with increasing depth. In stations 2 and 3, the phosphate concentrations increased at half-compensated depth. They again decreased at compensation depth, while the phosphate concentrations at stations 1 and 6 decreased at half-compensated depth and again increased at compensation depth. High concentrations of phosphate can cause eutrophication. However, the presence of phosphate in waters is significant for organisms, if the concentration is in accordance with the established quality standards (Ramadhan & Yusanti 2020).

Based on the research results, it was found that the phosphate concentration in the waters of Jatigede Reservoir was in accordance with the quality standard of Government Regulation No. 22 of 2021 class III, which is 0.03–0.10 mg L^{-1}. Regulation of the Minister of the Environment Number 28 of 2009 classifies fertility levels based on phosphate concentrations into 4 categories, namely <0.01 mg L^{-1} oligotrophic waters, 0.02–0.03 mg L^{-1} mesotrophic waters, 0.04 – 0.10 mg L^{-1} eutrophic waters, and >0.10 mg L^{-1} hypertrophic waters. Based on the Regulation of the Minister of the Environment Number 28 of 2009, the waters of Jatigede Reservoir are generally included in the eutrophic fertility level.

Acidity (pH). The pH value in the Jatigede Reservoir during the research ranged from 6.6 to 8.7. According to Effendi (2003), most aquatic biotas are sensitive to changes in pH and prefer a pH value of 6.5 to 8.5. Waters with pH values <4.8 and >9.2 can be considered polluted (Rukminasari et al 2014). High or low pH values in waters depend on several factors, including the decomposition process of organic matter at the bottom of the water (Haifa et al 2020). Based on the Indonesian Government Regulation No. 22 of 2021, the pH value in Jatigede Reservoir has met the class II and III quality standards, with a pH value of 6 to 9.

Table 3

Chemical parameters

Parameters		*Station*					
		1	*2*	*3*	*4*	*5*	*6*
Phosphate (mg L^{-1})	S	0.095±0.020	0.091±0.009	0.092±0.020	0.090±0.023	0.093±0.016	0.093±0.025
	H	0.093±0.009	0.106±0.021	0.100±0.017	0.094±0.02	0.094±0.018	0.091±0.020
	C	0.094±0.016	0.096±0.015	0.091±0.018	0.094±0.015	0.102±0.015	0.093±0.021
Acidity	S	7.12±0.26	7.45±0.57	7.10±0.26	7.01±0.10	7.12±0.30	7.03±0.13
	H	7.05±0.35	7.27±0.46	7.10±0.30	7.00±0.19	7.03±0.19	7.05±0.25
	C	7.02±0.09	7.31±0.68	7.14±0.26	6.96±0.12	7.01±0.06	6.99±0.12
BOD_5 (mg L^{-1})	S	8.38±1.22	8.38±4.75	12.16±3.80	10.54±1.99	7.03±2.44	5.95±1.32
	H	9.73±3.24	7.84±3.62	9.46±2.98	8.92±3.66	6.76±1.59	7.30±4.44
	C	7.30±2.24	7.30±4.20	9.19±2.44	7.03±2.44	6.76±5.27	6.76±2.90
DO (mg L^{-1})	S	5.38±0.66	5.20±0.53	5.07±0.76	5.58±0.70	5.77±0.95	5.65±0.90
	H	4.90±0.69	4.97±0.46	4.73±0.78	5.08±0.69	5.32±0.75	5.33±0.99
	C	4.58±0.92	4.77±0.48	3.98±0.69	4.38±1.1	4.84±0.71	4.43±0.37
Nitrate	S	0.023±0.004	0.028±0.008	0.025±0.007	0.025±0.011	0.023±0.009	0.017±0.008
	H	0.025±0.008	0.026±0.007	0.026±0.005	0.025±0.008	0.021±0.012	0.021±0.011
	C	0.022±0.004	0.028±0.008	0.025±0.006	0.019±0.007	0.021±0.008	0.023±0.010

Note: S - surface; H - half compensation; C - compensation; BOD_5 - biochemical oxygen demand; DO - dissolved oxygen.

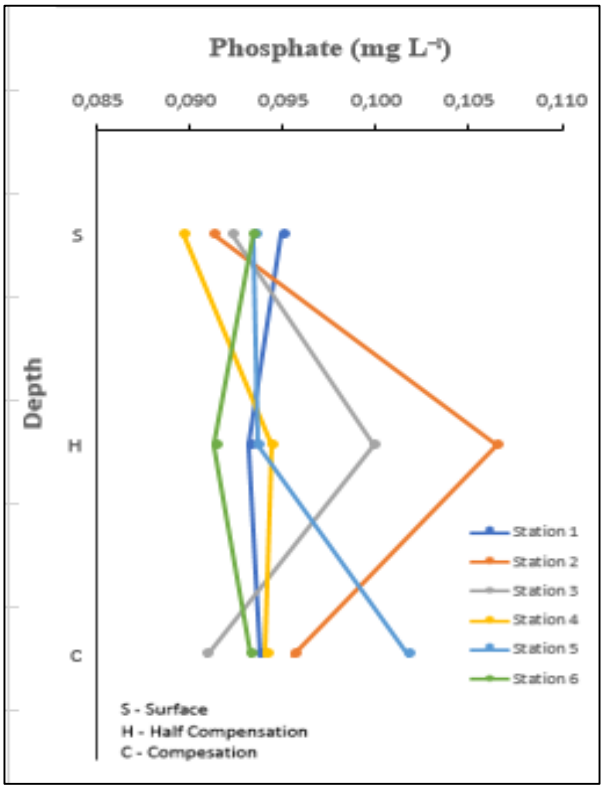

Figure 2. Average phosphate concentration in Jatigede Reservoir.

Biochemical oxygen demand (BOD$_5$). The BOD$_5$ concentration of Jatigede Reservoir waters ranged from 1.62 to 16.22 mg L^{-1}. The high concentration of BOD$_5$ in waters is due to accumulated organic matter from the household and agricultural waste to Jatigede Reservoir water bodies. This high concentration causes the bacteria at the station to require more oxygen for decomposing organic matter. A higher BOD$_5$ concentration value in water means an increased organic waste content in the water (Budiman 2010).

Dissolved oxygen (DO). DO observe during the research ranged from 3–6.7 mg L^{-1}. The concentration of DO in the waters of Jatigede Reservoir is in good condition and does meet the DO quality standard for waters. DO in water is usually less than 10 mg L^{-1} (Effendi 2003).

Nitrate. The concentration of nitrate obtained during the research ranged from 0.007 to 0.044 mg L^{-1}. The highest nitrate concentration (Table 2) was at station 2. Nutrients from the Cimanuk, Cimuja and Cijajaway Rivers cause the high concentration of nitrate at station 2, by carrying domestic and agricultural waste. According to Azzam et al (2018), nitrate concentrations in waters close to settlements result in domestic waste; in addition, rice fields also affect surrounding waters with fertilizers and insecticides with large amounts of nitrogen. The range of nitrate obtained during the study in the waters of Jatigede Reservoir is by the quality standards of the Government Regulation Number 22 of 2021, Class II and III, namely 0.75 mg L^{-1} and 1.90 mg L^{-1}, respectively.

Conclusions. The distribution of phosphate concentrations in the Jatigede Reservoir ranges from 0.053 to 0.137 mg L^{-1}, and meets the quality standard of the Government Regulation Number 22 of 2021, class III. The water of the reservoir is in the eutrophic fertility category based on the Regulation of the Minister of the Environment Number 28 of 2009. Furthermore, this research provides the information that can be used as the basis for the management of Jatigede Reservoir.

Acknowledgments. The authors would like to thank the Directorate of Research, Community Service and Innovation, Universitas Padjadjaran for providing an Academic Leadership Grant (ALG) for the implementation of this research.

Conflict of Interest. The authors declare that there is no conflict of interest.

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Received: 20 December 2021. Accepted: 03 March 2022. Published online: 25 July 2022.
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How to cite this article:
Herawati H., Zahidah Z., Sunardi S., Awalina S., Iskandar I., Sunarto S., Lukman L., 2022 Trophic level status of Jatigede Reservoir based on phosphate concentration. AACL Bioflux 15(4):1782-1789.