



## **Primary Productivity of Jatigede Reservoirs in Sumedang, West Java**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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### **ABSTRACT**

Jatigede Reservoir is a reservoir located in Sumedang West Java which is built for irrigation, raw water, power generation, tourism, and capture fisheries. This research aims to determine the value of primary productivity as one of the indicators of the water body feasibility of the Jatigede reservoir to capture fisheries activities. The study was conducted in August – September 2019. Sampling is carried out at 4 stations on the surface, half the depth of compensation, and the depth of compensation. Estimation of primary productivity using chlorophyll-a concentration measurement method. The results of measurement of water quality parameters in the Jatigede reservoir include transparency range of 19,5 cm – 116,5 cm, temperature with a spread of 26,58 – 27,48°C, pH with a range of 7,69 – 8,40, carbon dioxide with a range of 4,190 mg/L – 9,219 mg/L, current ranges from 0.136 m/s – 0,216 m/s, BOD5 with a range of 11,027 dissolved oxygen ranges from 6,4 mg/L – 7,1 mg/L, ammonia ranges from 0,006 mg/L – 0,039 mg/L, nitrates ranged from 0,168 mg/L – 0,216 mg/L, and phosphate range 0,139 mg/L – 0,185 mg/L. Results from the measurement of chlorophyll-a ranged from 0,035 mg/L – 0,062 mg/L. This results in showing the Jatigede reservoir of oligotrophic water because the primary productivity in the waters of the Jatigede Reservoir is relatively low if calculated based on the concentration of chlorophyll-a.

**Keywords:** *Primary productivity; chlorophyll-a; Jatigede reservoirs; water quality.*

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## 1. INTRODUCTION

Jatigede Reservoir has an area of ± 4122 ha and is located in Sumedang Regency, West Java. The reservoir is constructed by stem the Cimanuk River and is a multi-functional reservoir. This reservoir functions as a power plant, irrigation, and flood control [1]. One of the purposes of the building of the Jatigede reservoir is to be used as land for the social impact Society arising from the change of a land function. Capture fisheries become one of the sectors that can be developed as an alternative to community livelihoods in the Jatigede reservoir. The efforts that can be done for the reference of fish resources in the land general water is by the distribution of fish seeds and water burial [2]. The expansion of fish seeds is done to increase production derived from capture fisheries. For the fishing activities required the fertile waters with a considerable abundance of phytoplankton. This is because the fish that is stocked are expected to utilize phytoplankton as a natural feed.

Water quality is a parameter that needs to be considered in determining water worthy or not to capture fisheries activities. One of the expectations of water quality in a waterway is to look at the value of primary productivity. Primary productivity is the speed of the process of photosynthesis or carbon binding and the production of carbohydrates (organic substances) in certain units of time and volume [3]. In aquatic ecosystems, phytoplankton becomes one of the primary producer organisms that spread in the wider waters. Therefore the phytoplankton's significance in the waters is higher than those of the two other primary producers, namely Macrofit and Periphyton [4].

Phytoplankton converts inorganic substances into organic matter through the process of photosynthesis with the help of sunlight which is the result called primary production [5]. Phytoplankton contains chlorophyll – a which is an active pigment in plant cells that plays an important role in the process of photosynthesis of irrigation [3]. Chlorophyll-A is one of the parameters that determines the primary productivity in the water. The low concentration of chlorophyll-a concentrations is strongly associated with the environmental conditions of the water.

## 2. METHODOLOGY

### 2.1 Study Area

The research was conducted at Jatigede Reservoir, Sumedang, West Java, Indonesia. The study was carried out during August 2019 until September 2019 which is the dry season in Indonesia. Water quality observation carried out at the Aquatic Resources Laboratory (SDP) Faculty of Fisheries and Marine Sciences Universitas Padjadjaran Jatinangor. The determination of the station is done by the survey method and the sampling technique used is purposive sampling. Determination of research Station and sampling is chosen based on river water input flowing through Jatigede reservoir, including:

- Station 1 is an inlet of Jatigede Reservoir located in Sukamenak Village, Darmaraja, Sumedang Regency, West Java with a geographical location 6°55'58.8"S - 108°05'20.3"E. Station 1 is chosen because it is a water input area dominated by the Cimanuk River with an average depth of 2, 89 m.
- Station 2 is the central part, switching from the water input of the Cimanuk River to the central part of the reservoir. Station 2 has an average depth of 4.88 m. Station 2 is located in Leuwihideung Village, Darmaraja, Sumedang Regency, West Java with a geographical location of 6°54'40.1"S-108°05'46.4"E.
- Station 3 is the central part of the reservoir that receives water input from the Cimanuk River as well as other tributaries, such as Cinambo River, Cibayawak River, Cihonje River, Cicacaban River, and Cimuja River. The station has an average depth of 31.94 m. Station 3 is located in the village Jemah, Darmaraja, Sumedang Regency, West Java with a geographical location 6°53'06.8"S-108°06'11.3"E.
- Station 4 is an outlet of the Jatigede reservoir and is a zone of water outflow of the Jatigede reservoir from various water inputs. The station has an average depth of 53 m. Station 4 is located in the village Cijeungjing, Darmaraja, Sumedang Regency, West Java with a geographical location 6°51'32.6"S - 108°05'49.0"E.

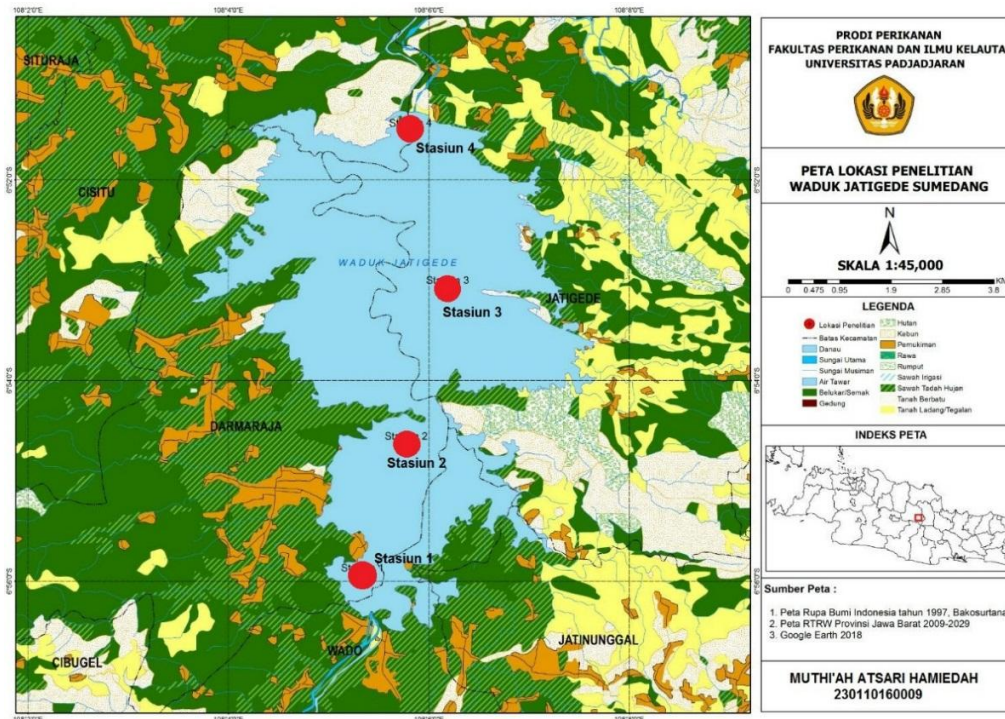


Fig. 1. Map of observation locations

## 2.2 Sampling and Water Quality Measurement

Water and chlorophyll-a sampling were carried out with seven days of five times samplings. Samples taken from 9 am to 2 pm. The water and chlorophyll-a taken at the four stations were carried on the surface section, at a depth of half the compensation, and the depth of compensation at each observation station. A sample of chlorophyll-A is taken by inserting 1 liter of water into the vial then the water is filtered using a filter paper to get chlorophyll-a in the laboratory. Measurements of water quality such as acidity degree (pH), CO<sub>2</sub>, and DO (Dissolved Oxygen) are measured in situ. While nitrate, phosphate, and BOD (Biochemical Oxygen Demand) are measured on the ex.

## 2.3 Primary Productivity Measurement

The primary productivity calculation method used is the calculation of the chlorophyll-a pigment concentration as follows:

$$\text{Chlorophyll-a} = \text{Ca} \cdot (v/V \cdot L)$$

Ca Obtained from the equation: 11,6 D665 – 1,31 D645 -0,14 D630

Description:

v = Acetone Volume used (mL)

V = Filtered water Volume to be extracted (L)

L = Cuvet length (cm)

D665 = Optical density at wavelengths 665 nm

D645 = Optical density at wavelengths 645 nm

D630 = Optical density at wavelengths 630 nm

## 3. RESULTS AND DISCUSSION

The results of primary productivity measurements based on the value of chlorophyll-a concentration on the four stations with three distinct depths obtained chlorophyll-a value ranged from 0.023 – 0.076 mg/L (Table 1). From the observations obtained the average value of the highest concentration was at the station 4 at a depth of half the compensation, which amounted to 0.062 mg/L and the average value of the lowest chlorophyll-a concentration was in the station 1 precisely at a depth of compensation of 0.035 mg/L.

The high value of primary productivity based on chlorophyll-a concentrations at Station 4 is influenced by the transparency of light entering the water used by phytoplankton for the photosynthesis process of 93,10 ± 18,49. The lower the transparency of light entering the water, the lower the primary productivity value is

generated. But if the value of transparency too high can also lead to the decreased value of primary productivity due to the nature of phytoplankton is photoinhibition. As shown in Table 2, on average, the resulting primary productivity value is no higher than the primary productivity value at half-compensation.

The lowest depth at the lowest research site is at Station 1 with a value of 2.89 m because station 1 is the closest location to the mainland. The highest depth at station 4 is 53 m. The depth of water will affect the inclusion of sunlight into the waters, the higher the depth than the diminishing sunlight that enters the waters and will affect the existence of phytoplankton also the ability of phytoplankton in photosynthesis that ultimately the value of its water productivity is lower in line with the higher the depth [6].

The water temperature in this location ranges from 26.58 – 27, 48°C. The temperature range is good for the growth of phytoplankton for photosynthesis. The optimum temperature range for the growth and development of plankton in the tropics is at a temperature of 20-30°C [7]. Temperature parameters should be noted considering that phytoplankton has optimum temperature and a certain tolerance range. The high temperature will damage chlorophyll-a in phytoplankton which causes decreased content of chlorophyll-a so that the value of primary productivity will decrease. Likewise, if the temperature is too low.

The current velocity in the waters of the Jatigede reservoir ranges from 0.13 – 0.21 m/s. The lowest average current value is at Station 2, which is 0.13 m/s, while the average highest current speed is at Station 3, which is 0.21 m/s. At Station 3, the wind speed is very high due to the distance from the mainland, so that on station 3 the average value of the current speed is higher than the other observation stations. Currents play an important role in the movement of nutrients in the waters. These nutrients are useful for the growth of aquatic organisms such as plankton. The utilization of the current movement by biota is a means of driving especially the biota that is not strong swimmers such as plankton [8].

Degree of acidity (pH) in the adaptation of organisms in the waters. The highest pH average value is at Station 3 at a depth of half the compensation and at station 4 at a depth of half the compensation, which is 8.4. While the lowest average value is at station 2 in the depth of

compensation, which is 7.69. The limit of tolerance of organisms to pH varies depending on physical, chemical, and biological factors [9]. The ideal pH for the life of phytoplankton ranges from 6.5 – 8.0, meaning the pH in the waters of the Jatigede Reservoir is ideal for the life of phytoplankton. High or low pH values of water depend on several factors, namely, the condition of gases in water such as CO<sub>2</sub>, concentrations of carbonate and bicarbonate salts, and the process of decomposition of organic matter at the bottom of the waters [10].

Carbon dioxide (CO<sub>2</sub>) is one of the important parameters in the area because its existence is needed for the photosynthesis process [11]. The highest average value is on the station 1 precisely on the surface, which is 9.21 mg/L, while the lowest average value of 4.19 mg/L is in 3 points, i.e. station 2 on the surface, Station 3 on the surface, and station 4 on the entire depth tested. The high CO<sub>2</sub> in Station 1 due to the process of decomposition of trees that have not been cleaned before the water filling process in the Jatigede reservoir.

The highest average value of BOD<sub>5</sub> concentration in the Jatigede Reservoir is at Station 1, which is 12.64 mg/L and the lowest average value of 4 stations is 11.02 mg/L. Organic waste in the form of wastes is the cause of the station 1 has the highest BOD<sub>5</sub> value compared to other stations. Based on the results of the observation during the research, Station 1 is an inlet reservoir area and there are community activities such as farming activities around station 1 that could potentially add organic material into the body of water. Also, before being flooded, in the area of Station 1 still obtained trees that are still in the process of decomposition and there is the rest of the building that is causing the increasing concentration of organic matter in the region. The large value of BOD<sub>5</sub> indicates the presence of micro-organisms in the outline of organic matter to describe the presence of high organic matter [12].

The average value of the dissolved oxygen concentration (the highest DO in the Jatigede Reservoir is at Station 3 on the surface of 7.1 mg/L, while the lowest one is at station 2 namely at the depth of half the compensation is about 6.4 mg/L. The low DO value on the 2nd station is affected by the temperature. The temperature on station 2 is quite high compared to the 3 and 4 stations, i.e. ranged between 27,06 -27, 46°C. When the temperature value rises then the

dissolved oxygen in the water will decrease. Oxygen in water is very important because it affects the life of organisms both directly and indirectly. The concentration of dissolved oxygen in the waters is associated with phytoplankton as a producer of oxygen through the photosynthesis process [13].

Nutrients become one of the important factors in the process of growth and reproduction of phytoplankton. The average value of the highest ammonia concentration in the Jatigede Reservoir is on the station 1 precisely at a depth of half the compensation is 0.040 mg/L, while the average concentration of ammonia concentrations is at the station 4 precisely at a depth of compensation of 0.006 mg/L. The high value of ammonia concentration in Station 1 is caused by the number of trees remaining in the decomposition process. One source of ammonia compounds in the waters comes from the metabolism of animals and the results of the decomposition of organic substances (plants and aquatic biota that have been dead) by bacteria [14]. Ammonia which is in the waters is largely the result and metabolic process of aquatic organisms and the process of decay of organic matter or organic waste such as household garbage and others by the carried-out bacteria. Ammonia concentrates in freshwater water should be no more than 0.02 mg/L [15]. High ammonia concentrations can be an indication of the contamination of organic substances derived from domestic waste, industry, and the runoff of agricultural fertilizers [7].

Based on the results of measuring the average concentration of nitrate (Table 2), Station 1 has an average value of the highest concentration of

nitrate in the depth of compensation, which is 0.256 mg/L. The high content of nitrate at this location is suspected because the station 1 is the inlet location of the reservoir adjacent to the agricultural area and the population settlements so there are still many organic. The high concentration of nitrate in the water can stimulate the growth and development of organisms in the water when supported by the availability of nutrients. While the lowest nitrate content is available at 4 stations on the surface with an average nitrate 0.168 mg/L. The concentration of nitrates more than 0.2 mg/L may result in the occurrence of eutrophication (enrichment) of water, which further stimulated the growth of algae and aquatic plants rapidly or called blooming [7].

Station 1 has an average value of the highest phosphate concentration precisely at a depth of compensation of 0.185 mg/L. Increasing phosphate compounds are influenced by the nutrient intake of the water catchment area, the activity of residents around the reservoir, and fishery activities. Based on the observation, at Station 1 there is a population activity in the form of agricultural activities as well as fishing activities in the form of arrest. The average value of the lowest phosphate concentration is at Station 3 which is at a depth of half the compensation with the average value of phosphate concentrations of 0.139 mg/L. Low concentrations of phosphate in Station 3 because phosphate is utilized properly by phytoplankton in the process of photosynthesis. phosphate is a form of phosphorus that can be utilized by plants and nutrients that are essential for plants so that it becomes a limiting factor and affects the productivity of the water [7].

**Table 1. Chlorophyll-a concentration in Jatigede Reservoir**

Station	Depth	Chlorophyll-a					A	Stdv
		Week						
		1	2	3	4	5		
1	S	0,027	0,039	0,044	0,047	0,065	0,044	0.013
	0,5 C	0,053	0,030	0,050	0,035	0,050	0,044	0.010
	C	0,030	0,045	0,031	0,028	0,041	0,035	0.007
2	S	0,023	0,070	0,067	0,076	0,067	0,061	0.021
	0,5 C	0,035	0,050	0,050	0,053	0,068	0,051	0.011
	C	0,028	0,072	0,033	0,064	0,047	0,049	0.019
3	S	0,024	0,072	0,076	0,069	0,051	0,059	0.021
	0,5 C	0,038	0,060	0,053	0,068	0,065	0,057	0.011
	C	0,032	0,050	0,066	0,063	0,039	0,050	0.014
4	S	0,026	0,055	0,067	0,041	0,064	0,051	0.017
	0,5 C	0,071	0,068	0,071	0,055	0,046	0,062	0.011
	C	0,038	0,071	0,067	0,031	0,063	0,054	0.018

A: Average, S: Surface, C: Compensation

**Table 2. Water quality at sampling station**

Parameters	Kedalaman	Stasiun				
		1	2	3	4	
Transparency (cm)	R	19,5-38,5	25-79	63-116,5	722-113	
	A	27,6±7,8	54,7±21,22	88,7±19,15	93,1±18,49	
Water Depth (m)		2,89	4,88	31,94	53	
Temperature (°C)	S	R	26,9-28,3	27-28,1	26,4-28,9	26,4-28,4
		A	27,48±0,54	27,46±0,5	27,02±1,06	27,26±0,73
	0,5 C	R	26,7-28	26,7-27,8	26,4-27,5	26,4-28
		A	27,38±0,53	27,32±0,45	27,02±0,53	27,04±0,59
	C	R	26,4-27,8	26,4-27,6	26,2-27,1	26,3-27,6
		A	26,96±0,59	27,06±0,51	26,58±0,36	26,72±0,6
Current (m/s)	R	0,14-0,16	0,05-0,25	0,06-0,43	0,04-0,20	
	A	0,152±0,008	0,136±0,092	0,216±0,148	0,142±0,069	
pH	S	R	7,04-8,77	7,94-8,74	7,88-8,57	7,79-8,46
		A	7,69±0,64	8,26±0,3	8,194±0,25	8,30±0,29
	0,5 C	R	7,57-8,7	7,73-8,65	7,9-9,38	7,81-8,76
		A	8,15±0,44	8,03±0,38	8,40±0,59	8,40±0,36
	C	R	7,04-8,62	6,5-8,67	8,18-8,44	7,78-8,51
		A	7,84±0,58	7,69±0,78	8,30±0,11	8,17±0,28
Carbon dioxide (mg/L)	S	R	4,19-12,57	4,19-4,19	4,19-8,38	4,19-4,19
		A	9,22±3,5	4,19±0	5,03±1,87	4,19±0
	0,5 C	R	4,19-12,57	4,19-4,19	4,19-4,19	4,19-4,19
		A	7,54±3,5	4,19±0	4,19±0	4,19±0
	C	R	4,19-12,57	4,19-4,19	4,19-8,38	4,19-4,19
		A	7,54±3,5	4,19±0	5,03±1,87	4,19±0
BOD <sub>5</sub> (mg/L)	R	4,86-21,08	6,48-24,32	6,48-17,84	3,24-17,84	
	A	12,65±6,00	12±7,12	12,32±4,95	11,03±6,00	
DO (mg/L)	S	R	6,2-7,9	5,4-8	5,8-7,9	6,1-7,3
		A	6,94±0,8	6,78-1,1	7,12±0,8	6,54±0,5
	0,5 C	R	6,5-7,9	4,8-7,9	6,2-7,5	6,5-7,7
		A	7±0,6	6,38±1,2	6,76±0,5	7±0,5
	C	R	6-7,9	5,5-8,2	6-7,9	6,1-8
		A	7±0,8	6,46±1	6,84±0,8	7±0,8
Ammonia (mg/L)	S	R	0,007-0,101	0,004-0,042	0,004-0,02	0,003-0,016
		A	0,039±0,04	0,013±0,016	0,011±0,006	0,009±0,005
	0,5 C	R	0,009-0,09	0,005-0,053	0,002-0,023	0,004-0,021
		A	0,04±0,031	0,018±0,02	0,013±0,009	0,010±0,008
	C	R	0,002-0,067	0,003-0,049	0,002-0,019	0,002-0,013
		A	0,027±0,026	0,013±0,02	0,011±0,008	0,006±0,005
Nitrate (mg/L)	S	R	0,209-0,279	0,16-0,314	0,133-0,222	0,121-0,2
		A	0,238±0,028	0,232±0,066	0,187±0,034	0,168±0,037
	0,5 C	R	0,148-0,357	0,126-0,286	0,116-0,259	0,13-0,237
		A	0,244±0,082	0,222±0,061	0,199±0,051	0,188±0,046
	C	R	0,15-0,37	0,162-0,321	0,159-0,251	0,152-0,221
		A	0,256±0,049	0,236±0,064	0,191±0,036	0,183±0,029
Phosphate (mg/L)	S	R	0,128-0,211	0,114-0,169	0,127-0,182	0,115-0,183
		A	0,161±0,031	0,148±0,02	0,156±0,023	0,148±0,027
	0,5 C	R	0,146-0,215	0,104-0,214	0,123-0,17	0,131-0,16
		A	0,174±0,026	0,152±0,04	0,139±0,019	0,141±0,012
	C	R	0,14-0,267	0,134-0,183	0,113-0,219	0,111-0,193
		A	0,185±0,049	0,152±0,019	0,15±0,041	0,142±0,033

R : Range, A : Average, S : Surface, C : Compensation

Based on the average chlorophyll-a value obtained, the Jatigede reservoir is classified as oligotrophic water. The classification is based on the trophic status of the water is chlorophyll at the range of 0 – 2 mg/L, classified as oligotrophic, 2 – 5 mg/L in Meso-oligotrophic, 5 – 20 mg/L is classified as mesotrophic, 20 – 50 mg/L classified as eutrophic and > 50 mg/L classified as Hyper-eutrophic [16] It can be said that the Jatigede reservoir has low primary productivity, as it has the abundance and content of chlorophyll-a phytoplankton in relatively low waters. The higher the primary productivity of water, the higher the ecosystem's support for many organisms, and the less the lower the primary productivity of eating, the lower the capacity of the ecosystem [4].

Some of the physics-chemical parameters affect the chlorophyll distribution of the Jatigede. Chlorophyll-a reservoir is one of the parameters that greatly determines the primary productivity in the water. The low concentration of chlorophyll is strongly associated with the environmental conditions of the water. Good water quality is a good living place for phytoplankton because the content of chlorophyll-a phytoplankton can be used as a high indicator of the low productivity of water.

#### 4. CONCLUSION

Primary productivity in the Jatigede reservoir is still relatively low with the average of each station and its depth of field is between 0.035 mg/L – 0.062 mg/L. Jatigede Reservoir is good for capture fisheries activities and aquatic organisms seen from the parameters of water quality include transparency of light, depth, current, temperature, pH, carbon dioxide, DO, BOD5, nitrogen, and phosphate affect the existence of phytoplankton and chlorophyll-a in the Jatigede reservoir, thereby affecting primary productivity.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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