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ASSESSMENT OF THE WATER QUALITY AND ENVIRONMENTAL MANAGEMENT IN JANGARI RESERVOIR WATERSHED USING SELECTED PHYSICAL, CHEMICAL, AND BIOLOGICAL PARAMETERS

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Abstract

This study examines water quality and environmental management in the Cirata Reservoir by using certain physical, chemical, and biological parameters associated with environmental management. The physical parameters measured were rainfall, temperature, Total Dissolved Solid (TDS), and turbidity. The chemical parameters measured are the degree of acidity (pH) and electrical conductivity (EC). While the biological parameter measured is the density of phytoplankton. The field survey was conducted as a data collection method supported by literature review and interviews. This research used quantitative methods with a qualitative approach. Water samples were taken at the location where water flows in the Cirata Reservoir from Purwakarta, Cianjur, and West Bandung boils down, namely in the Jangari area Bobojong, Cianjur. Samples were taken at two points about 200 m apart. Sampling was also carried out in harbor and fish breeding. The results showed that the Cirata reservoir water flow was polluted with high levels. It is indicated by TDS 102-129 ppm that means high inorganic content. Due to inadequate environmental management from the authorities and community activities that do not pay attention to environmental sustainability. Therefore, all related parties together with the community in the area around Cirata Reservoir, especially Jangari, have a key role in preserving the function. This study's results can enrich the literature on water quality and environmental management and provide input for local governments regarding reservoir management.

Keywords: Biological, Chemical, Environmental management, Jangari reservoir, Parameters, Physical, Water quality.

1.Introduction

Cirata is a reservoir covering an area of 6200 hectares of water and 7111 hectares of land. The reservoir is located in three districts in West Java (West Bandung, Cianjur, and Purwakarta), the middle reservoir of three cascade reservoirs in the Citarum River Basin. Having supplied the electricity demand for Java and Bali, Cirata turbine generates electricity power by 1008 MW. The dam has 125 m high and 500 m long, with a capacity of 2165 million m^3, and receives a water intake of 158.04 m3/s. The dam's maximum elevation is 221 m, and its water level is 211.78 m [1]. The Jangari Reservoir, which is located in Cianjur, is included in the upstream area of the water flow from the Cirata reservoir, which eventually flows into Karawang, Kalilamang and divides Jakarta to flow into the sea, which is a series of cycles of rainwater travel from sea to the mountain and back to the sea.

The Jangari Reservoir is famous for the goldfish and tilapia farming in this area. Unfortunately, the Cirata reservoir flow has decreased water quality [2-4]. Based on the Decree of the State Minister for the Environment No: 115 of 2003 concerning Guidelines for Determining Water Quality Status. Water quality is the water quality level that indicates polluted conditions or good conditions at a water source within a certain time by comparing with the established water quality standards. Water pollution is indicated by a decrease in water quality to a certain level that causes water to not function according to its purpose. The purpose of a certain level mentioned above is the water quality standard that is determined and serves as a benchmark to determine whether water pollution has occurred [5].

The cause of the decline in water quality is the entry of waste originating from agricultural, domestic, industrial, transportation, livestock, and fishery waste. There are types of waste that enter the water containing heavy metal, such as industrial waste, transportation waste, and agricultural waste. Heavy metal is harmful to the aquatic environment and organisms, widely distributed in the Cirata Reservoir [4]. Polluted water is characterized by changes such as temperature, pH or hydrogen ion concentration, color, smell and taste of dissolved water, sediment presence, presence of colloids, presence of dissolved materials, presence of microorganisms, and increased water radioactivity [6].

In environmental management around the reservoir, people who have the potential to be affected and people living in the catchment area must be involved. The affected communities below the reservoir in elevation have a high potential hazard if there is damage to the dam, such as flash floods. Communities living in the catchment area need to be given an empowerment program to control erosion and sedimentation [7]. Previous researches for assessing water quality related to environmental management in reservoir systems are also limited. Indeed, selected physical, chemical, and biological parameters create a holistic review on the topic. Some research aimed to evaluate the physical and chemical parameters of Cirata Reservoir. Research results show quantitative results in the range of physical-chemical parameters of waters in Cirata Reservoir [8-10]. However, the study did not explain its relations with environmental management. In line with this, some research was conducted to analyze water quality, and the only Method highlighted its relation with the fisheries [10-12]. Therefore, this study is needed to be conducted with a more holistic approach, including physic, chemical, and biological related to environmental management.

This research aims to test water quality and environmental management in the Cirata Reservoir water flow using certain physical, chemical, and biological parameters associated with environmental management. It is expected to find a more holistic approach toward best management recommendation on Cirata Reservoir watershed, especially in Jangari area. The method used was quantitative with a qualitative approach. Field surveys and interviews were conducted to obtain primary data. In addition, a literature review was performed to support data analysis.

2. Research Method

The locations used for sampling were two locations in the Jangari area, Cianjur, the watershed of the Cirata reservoir where the water meets from 3 districts (Purwakarta, Cianjur, West Bandung) with a distance of 200 m. As a comparison sample, water was taken in the middle (which is away from human activities) and in the upstream part of the Jangari reservoir (bustling of human activity), as shown in Fig. 1.

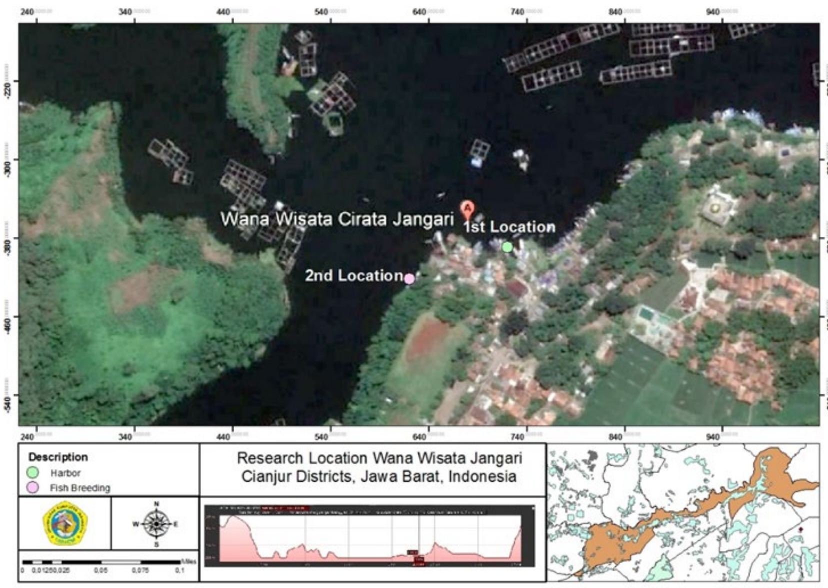

Fig. 1. Research location.

The equipment used in this study was a haemocytometer, conductivity meter, pH meter, and thermometer. In this study, measurements of TDS, electrical conductivity, pH were carried out in each sample. Measurement of pH and temperature is measured directly at the sampling location using EZ-9908. The measurement was repeated three times. Electrical conductivity measurements are carried out with a conductivity meter.

Water samples were also taken to observe the density of phytoplankton using a haemocytometer. The stages for phytoplankton analysis were that the sample is taken using a 1 ml pipette. Then, put or dropped into a haemocytometer for three drops or repetitions. The sample that had been put into the haemocytometer is then covered using a glass preparation. Samples that had been inserted into the haemocytometer are then observed using a microscope with a magnification of 10×10. The samples were observed using a microscope to determine the density of phytoplankton. The method of observing the density of phytoplankton with a haemocytometer with a magnification of 10×10.

3. Results and Discussion

3.1. Physics parameters

a. Rainfall

The statistical analysis of rainfall in the Jangari reservoir shows significant rainfall differences in March, August, and October each year. In March's rainy season, the rainfall tends to be high, with an average of 320.75 mm/year. Meanwhile, the lowest rainfall occurs in August during the dry season, with 35925 mm/year. Indonesia's rainfall has seasonal and inter-year variability, where the rainfall tends to be high in the rainy season, while the lowest rainfall occurs in the dry season. The average rainfall pattern in Jangari reservoir tends to have a monsoon pattern where the highest rainfall occurs in November, December, January, February, and March. Meanwhile, April to September has the lowest rainfall (below 200 mm/month). Rainfall is one factor that can affect water quality in the Jangari reservoir, where high rainfall can be a medium for transporting pollutants from the surface such as bacteria and other microorganisms into the reservoir stream. Rainfall with a certain level is also able to sweep the contents and contaminants on the soil's surface into the reservoir stream so that it affects the number of contaminants and pollutants.

b. Temperature

The results of direct temperature measurements in the Jangari reservoir show that the water temperature is relatively the same between stations 1 and 2, which is in the range of 29-29.9 ° C. Due to the heat exchange between wind and air, the intensity of sunlight, and the canopy of the surrounding vegetation. In general, the surface temperature of the waters ranges from 28-31 °C. Therefore, the temperature of the Jangari reservoir waters is categorized as at normal limits and in accordance with the biota's needs and ecosystem in it. Temperature is caused by heat in the body water surface due to solar radiation absorption by the water surface. The temperature difference is caused by antopogen factors (human activities) such as disposal of waste into rivers and loss of protective water bodies. Trees as water protection have been lost due to land conversion into residential areas. The existence of human activities around the river causes an increase in water temperature [13]. It is consistent with the results of higher temperature measurements in locations with high human activity, namely 29.9.

c. Total dissolve solid (TDS)

The TDS in the Jangari reservoir ranges from 102-129 ppm, which means that the inorganic content is high. It shows that the water quality in the Jangari reservoir is classified as not good for consumption. The water quality in the Jangari reservoir includes water that has inorganic content. The inorganic content will be absorbed into the body but cannot be broken down to be excreted, affecting deposition in vital organs. The TDS range in the Jangari reservoir, which is relatively high, shows that absorbed sunlight's penetration, will decrease, thereby reducing water productivity. One reason for reducing the penetration of absorbed sunlight is a large amount of garbage that enters the waters, which blocks sunlight from being absorbed by the waters and causes the watercolor's appearance to look cloudy [14, 15].

Water quality standards or water sources are the permissible levels for substances or pollutants in water, but the water still serves its designation. Determination of water quality standards is based on the water source's carrying capacity at the water source, which is adjusted to the water designation as follows: a. Group A, water that is used as drinking water directly without any prior treatment. b. Category B, water that can be used as raw water to be processed as drinking water and household needs. c. Category C, water that can be used for fisheries and livestock purposes. d. Group D, water that can be used for agricultural purposes and can be used for urban business, industry, and hydroelectric power. In addition, to water quality standards, there is also the term liquid waste quality standards, namely the limit of permissible levels for pollutants or substances to be discharged into water or water sources so as not to result in exceeding the water quality standard. The determination of the liquid waste quality standard is determined by considering the maximum load that can be received by water and water sources and is divided into four categories of wastewater quality standards, namely Group, I, II, III, and IV. The number of pollution levels allowed for each parameter of water quality and wastewater can be seen in the guidelines for determining environmental quality standards issued by the Office of the State Minister for the Environment.

Chemical Parameters

a. Power of hydrogen (pH)

The power of hydrogen (pH) is a chemical parameter that functions to determine whether water is good or bad. In addition, variations in pH values can affect stability, biota, and aquatic ecosystems. The high pH value greatly determines the dominance of phytoplankton, affecting the productivity level of water. The pH value measurement in the Jagari reservoir shows a range between 6.17 and 6.21, which is categorized as poor. A good pH category is in the range of 6.5 - 8.0 as the safe limit for the pH of the waters for biota and ecosystem life. The Jagari reservoir is not suitable for aquaculture because the pH tolerance limit for fish farming ranges from 6.5 to 8.5 [14].

b. Electrical conductivity (EC)

EC is an indicator of the water's ability to continue electricity, which is influenced by the number of salts and mineral content dissolved in the water. Based on the conductivity value, drinking water has conductivity values ranging from 42-500 μmhos / cm. On the other hand, the water conductivity value in Jangari reservoir ranges from 206 - 241 μmhos / cm. It shows that the water in the Jangari reservoir is still within the water limit for consumption based on its electrical conductivity [16, 17].

Biological Parameters

Based on the physical and chemical factors, phytoplankton density is known in Jangari Reservoir. The diversity of phytoplankton species is determined based on the season, namely Cyanobacteria in summer. Meanwhile, in other seasons the dominant types of phytoplankton found are Chlorophyta and Bacillariophyta [18]. The phytoplankton density in the Jangari Reservoir is between 36590-103 and 40710 · 103 ind /l. It shows that the diversity of phytoplankton species in the Jangari Reservoir is relatively high [19]. It is indicated by the physical condition of the water, which is cloudy and looks green. Besides, the phytoplankton in the Jangari Reservoir causes turbid water caused by non-organic particles. These inorganic particles are generated from waste pollution in the air as shown in Fig. 2.

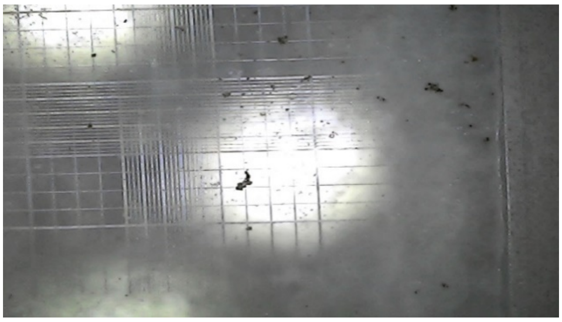

Fig. 2. Water particle.

3.2. Environmental management

Environmental Management in the Wana Wisata Jangari area, which is in the Bobojong Village area, Mande District, Cianjur Regency, has three main priorities: Management of Clean Water Needs, Wastewater, and Garbage. The condition of the area in the Wana Wisata Jangari area has environmental conditions that are not well maintained, especially in the waters' condition. The water quality condition in this area has a high level of pollution, as seen from previous data regarding water quality. The main wastes that pollute the aquatic environment in this area are household and social waste.

a. Clean Water Management

Currently, the need for clean water is one of the most important factors in the community's welfare in an area. Due to the increasingly scarce availability of clean water due to the high water pollution level in the world, it is due to the increasingly scarce availability of clean water. Therefore, the United Nations set water and sanitation as one of the program's goals for sustainable development goals [20]. Based on data on the development of the population of Bobojong Village in the previous four years, it was found that the projection of clean water demand in this village in the next ten years (2021 - 2031) is 5933912 litres/day. The increasing need for clean water every year is 5.46% or 252237 litres/day. This projection calculation is based on the geometric population projection method and adjusted to Indonesia's standard of clean water demand. The standard of clean water needs in Indonesia set by the Directorate General of Human Settlements of the Ministry of Public Works is the need for clean water for households of 320 litres/day/head of family, social and office facilities by 15%, commercial facilities need at 15%, industrial facilities, fire extinguisher, and clean water leak reserves account for 10% of the total household needs is shown in Table 1.

Table 1. Projected clean water needs.

Year	Population	Household (Head of Family)	Clean Water Needs (Liter/Day)		Total (Liter/Day)
			Household	Socio-Economic	
2021	15065	6598	2111440	1372436	3483876
2022	15126	6959	2226930	1447505	3674435
2023	15187	7340	2348737	1526679	3875416
2024	15249	7741	2477207	1610184	4087391
2025	15311	8165	2612703	1698257	4310961
2026	15373	8611	2755611	1791147	4546759
2027	15435	9082	2906336	1889118	4795454
2028	15498	9579	3065305	1992448	5057753
2029	15561	10103	3232969	2101430	5334398
2030	15624	10656	3409803	2216372	5626175
2031	15687	11238	3596310	2337602	5933912

The increasing need for clean water and difficulties in obtaining water suitable for consumption requires clean water management in Bobojong Village through water demand management. Management of water demand that can be carried out includes conservation and implementation of groundwater consumption policies. Efforts to implement policies such as increasing the tariff for clean water use in various fields, particularly the industrial sector, must be immediately considered. The increase in tariffs in several countries has proven to be helpful in water management and the sustainability of water ecosystems [21]. Besides, the availability and maintenance of facilities and infrastructure such as water treatment plants must also be considered. It is because municipal water treatment plants can generally produce drinking water that is suitable for consumption. However, it does not close the opportunity that drinking water can contain Escherichia coli as much as 2–30% during the distribution and storage process [22]. One effort that can be done is to implement Smart Water Management that combines innovative technology, such as information technology, control, and monitoring for water exploitation, at the regional to village levels.

Smart Water Management's application can assist in the realization of more sustainable water services by reducing financial losses through innovative public service models. In addition, public service agencies can help build a complete database to identify areas that have leaked drains or illegal water connections. For the public, wireless data transmission can help analyse water consumption and determine the amount of water bill [23]. Smart Water Management can be done by regularly updating the geographic information system data related to the distribution of clean water infrastructure. The agency provides monitoring technology at every location for means of Spring Protection (PMA), Hand Pump Well (SPT), Dug Well (SGL), and community-based clean water infrastructure to monitor drainage damage and others. Then each house is given a tool to detect the use of clean water and the tariff to be paid. These things will help in monitoring and reducing the excessive use of clean water.

b. Wastewater management

Monitoring and management of wastewater are one of the main factors for water pollution after garbage. Wastewater that is discharged directly without going through the management process into the river results in the content of ammonium ions contained in the wastewater directly mixing into the water source (upstream) [23]. Any wastewater generated by household, social, and economic activities has increased every year in line with the increasing need for clean water.

Based on the need for clean water in Bobojong Village, it was found that the increase in the volume of wastewater would be the same as the need for clean water in the next 10 years (2031), namely 5.4%. The average volume of wastewater that will be produced until 2031 is 166629 litres/day. This calculation is carried out by referring to the standard volume of wastewater produced every day based on the type of activity and the results of population projections by the Directorate General of Human Settlements of the Ministry of Public Work. The volume of wastewater originating from households is 70% of the domestic need for clean water. On the other hand, the volume of wastewater generated from social and economic facilities is 60% of non-domestic clean water needs. Wastewater volume projection is shown in Table 2.

Table 2. Wastewater volume projection.

Year	Population	Household (Head of Family)	Wastewater Volume (Liter / Day)		Total (Liter/Day)
			Household	Socio-Economic	
2021	15065	6598	1478008	823462	2301470
2022	15126	6959	1558851	868503	2427354
2023	15187	7340	1644116	916008	2560124
2024	15249	7741	1734045	966111	2700155
2025	15311	8165	1828892	1018954	2847847
2026	15373	8611	1928928	1074688	3003616
2027	15435	9082	2034435	1133471	3167906
2028	15498	9579	2145713	1195469	3341182
2029	15561	10103	2263078	1260858	3523936
2030	15624	10656	2386862	1329823	3716685
2031	15687	11238	2517417	1402561	3919978

The main problem of wastewater management is limited land and funds. However, currently, wastewater management can be done by providing algae ponds based on mixed lagoon systems. This system will maximize wastewater treatment as a trigger for algae growth to produce oxygen production to remove nitrogen and organic waste in wastewater [24]. Apart from using algae ponds, another system currently being used is a separate infrastructure planning system between household food waste management and wastewater [25]. The basic efforts that can be made in waste management, especially household waste, are irrigation, reuse of household wastewater for plant water activities, use of eco-sanitation, and provision of planted filters.

c. Waste management

Currently, the level of water pollution is caused by dumping garbage into waterways or rivers. Garbage collected may not be separate, so most of the waste ends up in landfills without going through the recycling process [26]. The same thing happened in the Wana Wisata Jangari area, which is located in Bobojong village. In this area, garbage is allowed to pile up, and even a few people dispose of household waste and other activities directly into the Jangari reservoir stream. Based on calculations using standard clean water needs by the Directorate General of Human Settlements of the Ministry of Public Works, it was found that the volume of waste in this area in 2031 is predicted to reach 58826 m^3. The volume of waste is calculated according to the provisions of ± 3 m3 of household waste, ± 10% of total household waste, and ± 5% of total household waste. The projection of waste volume is shown in Table 3.

Table 3. Projection of waste volume.

Year	Population	Household (Head of Family)	Wastewater Volume (m^3/ Person / Day)		Total (m^3)
			Household	Socio Economic	
2021	15065	6598	45194	11299	56493
2022	15126	6959	45378	11344	56722
2023	15187	7340	45562	11390	56952
2024	15249	7741	45746	11437	57183
2025	15311	8165	45932	11483	57415
2026	15373	8611	46118	11530	57648
2027	15435	9082	46305	11576	57882
2028	15498	9579	46493	11623	58116
2029	15561	10103	46682	11670	58352
2030	15624	10656	46871	11718	58589
2031	15687	11238	47061	11765	58826

The higher the volume of waste generated; the waste management must also be improved. In some countries, the waste management commonly used is sorting organic and non-organic waste. This waste sorting is carried out to facilitate the waste recycling process carried out by related agencies. In addition to separating organic and non-organic waste dumps, another step that can be taken is managing waste into a solar canter. The waste is first compacted then integrates with solar photovoltaic (PV) sources to increase the waste storage capacity [27]. Another effort that can also be done to manage waste is by utilizing information technology. The utilization of this information technology uses the concept of a cloud-based smart waste management mechanism. This concept is done by providing a sensor on the trash; the sensor will notify the waste level's status in real-time and inform the cloud system. Then, stakeholders can access the data they need from the cloud to help with city administration and waste management.

The data generated from the cloud system can also assist in route optimization and selection of waste collection paths according to the temporary landfill's capacity status, thus helping in fuel efficiency and time to landfill [28]. Based on several considerations of the waste management concept, Bobojong village needs waste management by providing a temporary final disposal site specifically in the area. This is because Bobojong village's distance, especially the Wana Wisata Jangari area, is close to the Jatiluhur reservoir flow, triggering the potential for direct waste disposal to the Jati Luhur reservoir stream. Building a landfill will use the concept of a cloud system to provide schedule information for non-organic waste collection and the use of solar photovoltaic (PV) in compaction of the volume of waste before being transferred to a landfill. On the other hand, organic waste will be processed directly into the compost.

4. Conclusion

The research concluded that water quality in Jangari Reservoir is categorized as a water pollutant and cannot be consumed. Physics, biology, and chemical parameters have not reached minimum water quality standards as drinking water and fish cultivation. As the results of high inorganic content (Temperature: 29-29.9 ° C; TDS: 102-129 ppm; pH: 6.17 and 6.21; EC: 206 - 241 µmhos / cm) in the water. It is due to waste volume that is thrown away into the water. Besides, in the future, the community in Bobojong Village require a water clean of 5933912 litre/day. Meanwhile, wastewater produces in Jangari Reservoir (Bobojong Village) as much as 3919978 liter/ day, and 58826 m^3 for waste volume. Therefore, three points of environmental management are required, namely clean water management, wastewater management, and waste management.

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